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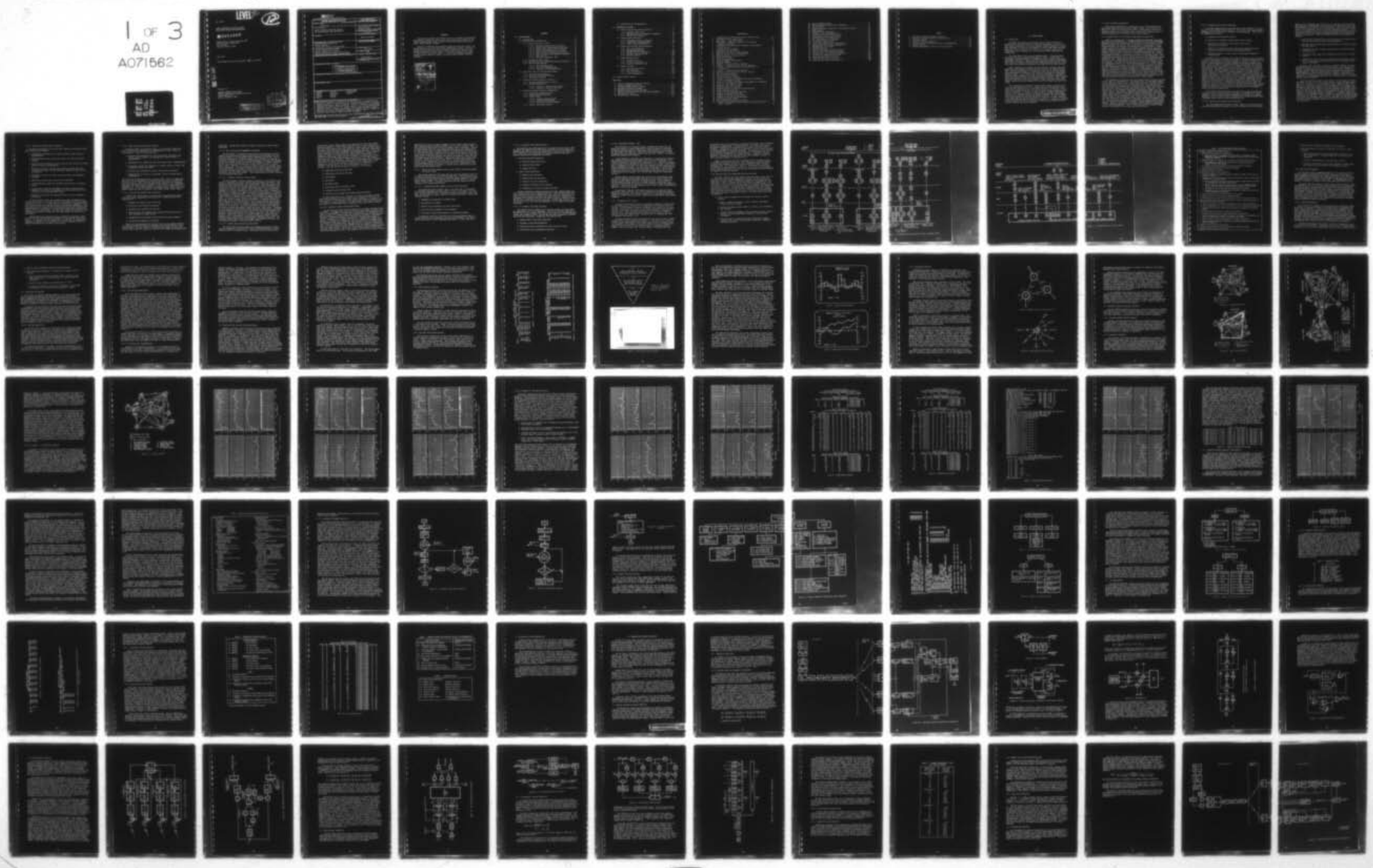

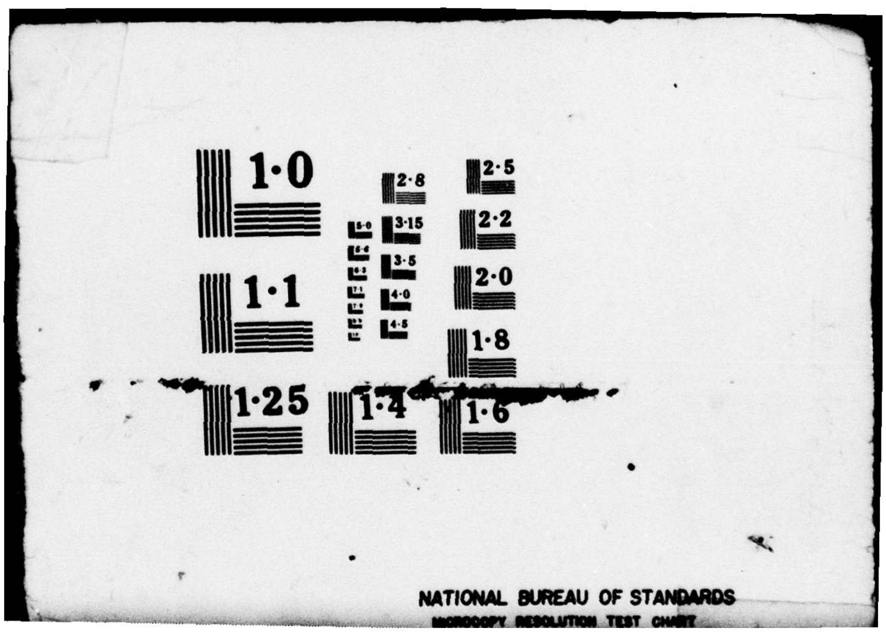
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HYBRID COMPUTER SIMULATION STUDIES FOR SYSTEM CONTROL AND TRANSMISSION

Computational Sciences Department
Martin Marietta Corporation
P.O. Box 5837
Orlando, Florida 32855

June 1978

Interim Report for Period September 1977 to June 1978

Prepared for

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This report documents the results of the first 9 months of simulations and studies in support of system control and transmission systems for the Defense Communications Agency, Reston, Virginia. Section 1.0 describes and documents simulation and study results for system control of the near-term Defense Communication System. Section 2.0 describes and documents the hybrid computer simulation of digital transmission systems and software support. Section 3.0 discusses remote terminal support provided the ~~DCEC~~ Defense Communications Engineering Center.

FOREWORD

This report documents the results of the first 9 months of simulations and studies in support of system control and transmission systems for the Defense Communications Agency, Defense Communications Engineering Center, under contract *DCA100-77-C-0061*.

Section 1.0 describes and documents simulations and study results for system control of the near-term Defense Communication System. Section 2.0 describes and documents the hybrid computer simulation of digital transmission systems and software support. Simulations developed in Sections 1.0 and 2.0 have been made available to the Defense Communications Engineering Center at Reston, Virginia, via remote hybrid computer terminal interface.

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Appendixes

ILLUSTRATIONS

TABLES

1.0 SYSTEM CONTROL

1.1 Introduction

The effort and results of the System Control Study for the first 9-month phase of Contract DCA100-77-C-0061 are documented in Section 1.0. This study is comprised of six tasks oriented toward utilization of simulation techniques for study and development of control algorithms, real-time human controller interaction, and evaluation of controller displays and alternative control techniques for the near-term Defense Communications System (DCS).

The first phase of the contract addresses Task 1 - Specification of Controller Task and Performance Requirements, Task 2 - Specification of Experimental Design Parameters for Network and Traffic Control Simulations and Studies, and Task 3 - Human Controller Oriented Simulations and Studies. These tasks are primarily associated with human engineering aspects of system control and include both simulation and analysis of the near-term DCS.

Task 1 consists of an analysis of system control functions and information flow requirements to define specific roles for the human controller. Task 2 involves development of a simulation study plan to evaluate parameters associated with system control functions and controller requirements defined in Task 1. Both Tasks 1 and 2 involve enhancement of the Martin Marietta network simulator to include interactive controller capability and near-term DCS system control and overseas network functions. Task 3 implements the simulation study plan developed in Task 2 and results in recommended display and control designs for near-term DCS human controller functions.

Area Communications Operations Center (ACOC) network controller functions are described in section 1.2, capabilities and deficiencies of the near-term DCS configuration are analyzed in section 1.2, data base requirements are discussed in section 1.3, and controller display designs are presented in section 1.3. As part of Tasks 1 and 2, extensive enhancements (section 1.5), have been made to the network simulator that was developed under Contracts DCA100-74-C-0039 and DCA100-75-C-0058. In Task 3, display and control designs have been developed for support of the ACOC controller in the near-term DCS and are described in section 1.3. Section 1.4 presents baseline Overseas AUTOVON and controller scenarios which demonstrate controller displays and control sequences.

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1.2 Near-Term DOCC Configuration

This section discusses the configuration of the present Defense Communications Agency Operations Control Complex (DOCC). The current information flow concept is outlined and specific recommendations presented for upgrading network control equipment and procedures with emphasis placed on the Area Communications Operations Center (ACOC) functions.

1.2.1 System Control in the Defense Communications System (DCS)

Since the overseas DCS is a complex communications network comprising many interrelated subsystems, a coordinated method of real-time performance assessment and control is essential for ensuring reliable transfer of information throughout the network. DCS system control is designed to provide the means by which the various DCS subsystems are operated under a common control system for the purpose of allocating available network resources to achieve maximum end-to-end performance (as compared with predetermined performance criteria) under normal and stressed operating conditions. Typical network stresses consist of variation in traffic distribution or intensity and equipment outages or disruptions from natural or man-made causes. Exercising effective network control entails the collection of meaningful system performance data, processing and display of data, decision-making through analysis of data, implementation of control actions, and evaluation of network response. The basic operational concept for near-term system control is decentralized control with centralized management; i.e., control actions are implemented at the lowest level that effectively alleviates the stress, and network management directives originate at higher control and support centers. This structure assumes minimum control implementation delay and maximum survivability. Control limitations or restrictions are imposed by near real-time directives issued at higher level control centers to provide high network visibility and coordination by system control functions. This facilitates optimum utilization of all available network resources and provides the greatest likelihood of survival for critical traffic.

The fundamental hierarchical near-term system control structure consists of five levels of responsibility. The highest level is the Defense Communications Agency Operations Center (DCAOC), which provides long-term and predictive management functions for the worldwide DCS. The second level is occupied by the Area Communications Operations Center (ACOC), which provides near real-time resource allocation and network control functions. This second level is the principle intratheater coordinating element for internetwork control. The Regional Communications Operation Center (RCOC) provides a function similar to the ACOC for smaller subnetworks. The Facility Control Office (FCO) is responsible for sector level coordination. The nodal control element is the Technical Control Facility (TCF), which is responsible for real-time traffic and routing control under restrictions imposed by the FCO. The station-level elements are responsible for monitoring and controlling the switch and transmission equipment to ensure maximum resource availability. Specific functions of the system control elements are considered in the following paragraphs. Most of these functions are currently implemented or are proposed for the near-term system control.

1.2.1.1 Worldwide System Control Functions

The Defense Communications Agency Operations Center (DCAOC) is the top level of the DCS system control hierarchy. Its crucial roles involve network management and long-term traffic analysis and system upgrade. These roles are summarized as follows:

1 Coordination of worldwide services

2 Direction of subordinate theater-level control actions

3 Analysis of data base for trend analysis and control effectiveness evaluation

4 Prediction of worldwide traffic and network anomalies with contingency planning to alleviate resulting disturbances

5 Predictive analysis to assure timely and appropriate upgrade of DCS facilities.

The DCAOC is also responsible for designing temporary network reconfigurations in anticipation of predictable events. The DCAOC functions may also include trending analysis and traffic demands on seasonal and predictive bases to ensure appropriate network upgrading and seasonal resource allocation. Since the DCAOC is responsible for long-term analysis and planning, real-time data base acquisition is not necessary. Therefore, it is anticipated that data base update will occur at most daily, and only through the several ACOCs. However, complete traffic, transmission system routing, and control statistics probably will be made available to the DCAOC for consecutive intervals of time to permit evaluation of perturbation effects and control effectiveness. The specific interval is subject to evaluation, although the range of from 10 minutes to 1 hour appears appropriate considering current traffic levels of the DCS networks. Processor requirements at the DCAOC will include extensive statistical analysis for traffic and control evaluation and prediction. Considerable medium-fast access storage capability will also be required to store the raw and refined data base. A comprehensive simulation of the DCS and its subsystem also may be considered at DCAOC for evaluation of potential network upgrades and for development of crisis-oriented contingency plans.

Since DCAOC operations generally preclude real or near real-time considerations, these operations need not be directly implemented in the DCS simulator. Rather, potential DCAOC management, contingency, and upgrade decisions can be evaluated using the simulation with projected traffic data, contingent stress, and/or control directed policies.

1.2.1.2 Theater Level System Control Functions

The Area Communications Operation Center (ACOC), as envisioned in the near-term system control concept for the DCS, provides near real-time data

analysis, fault isolation, and control for the principal DCS networks AUTOVON, AUDODIN, and AUTOSEVOCOM) in coordination with common-user facilities (DEB and DSCS) at the theater level of operation. ACOCs are currently operational for the European, Pacific and Western Hemisphere theaters. In the Pacific, some ACOC functions are divided among Regional Communication Operation Centers (RCOCs) to alleviate problems associated with the large geographical area involved. Principal ACOC/RCOC functions are summarized as follows:

1 Direction and coordination of traffic, routing, and allocation control actions for sector levels of responsibility

2 Real and near real-time monitoring and analysis of theater, sector, and nodal status

3 Coordination of fault isolation and restoral activities affecting multiple sectors

4 Coordination with common user equipments within theater of responsibility

5 Assumption of lower level system control responsibilities as necessary to assure system control survivability in a degraded system control environment.

Although current ACOC/RCOC functions for AUTOVON, AUTODIN, and AUTOSEVOCOM subnetworks tend to be isolated and distinct, the potential incorporation of common-user facilities, such as represented by the Digital European Backbone (DEB) and Defense Satellite Communication System (DSCS), make integration of these network functions necessary. Integration of system control functions also should serve to enhance system control survivability by providing additional paths for information flow in a degraded system control environment.

Since near real-time analysis and control are vital functions of the ACOC under the near-term system control concept, timely data base information flow is essential. It is anticipated that a complete traffic data summary on a short-term interval (5 to 15 minutes) will be required. System control information channels should be available from attendant FCOs and also from the nodal elements to provide redundancy for network survival. Directive flow paths also should be made available to each FCO and nodal element in the associated theater or subtheater. To enhance network survivability, each ACOC/RCOC should be capable of assuming the essential functions of one or more FCOs. In the Pacific, the ACOC also should be capable of assuming the responsibilities of one or more RCOCs, and the RCOC should be able to control coordinate theater level functions in the absence of ACOC directives.

1.2.1.3 Sector Level System Control Functions

The primary functions of the sector level element, the Facility Control Office (FCO), are as follows:

1 Coordination and direction of control actions at nodal levels of responsibility

2 Monitoring and analysis of real-time status of nodal and station elements

3 Direction and coordination of fault isolation and restoral activities within the area of responsibility

4 Direction of traffic, routing, and allocation control for nodal elements under directives and limitations imposed by higher levels of authority

5 Processing of nodal and station level data base with forwarding to ACOC/RCOC

6 Receiving and acting upon directives from ACOC/RCOC

7 Coordination with common-user equipment within sector of responsibility

8 Coordination of data base management and control directives with adjacent sector elements as necessary to ensure system control survivability in event of ACOC/RCOC failure

9 Assumption of adjacent FCO responsibilities in event of adjacent FCO failure.

The FCO processes traffic and equipment data bases and forwards both raw and refined traffic, routing, control, and equipment status to the associated ACOC or RCOC. It is responsible for directing and coordinating fault isolation and restoral of failures within its operational boundaries. It is also responsible for directing and coordinating control actions between nodal elements within the constraints of directives and restrictions issued from higher levels of responsibility. The FCO, under higher level direction, also coordinates allocation of common-user facilities within its sector of responsibility.

Limited intersector communication and coordination capability should exist at the FCO to enhance DCS survivability in the event of ACOC or RCOC failure. In addition, each FCO should have the capability of extending its boundaries of operation to incorporate all or part of adjacent sectors to enhance survivability in the event of FCO failure.

1.2.1.4 Nodal Level System Control Functions

The nodal element of DCS system control is the Technical Control Facility (TCF) which is responsible for implementation of most system control functions. Typical TCF functions are:

1 Direction and coordination of real-time routing, allocation, and traffic control actions to be implemented at station level of responsibility

2 Coordination with common-user facilities within area of responsibility

3 Monitoring, storage and transmittal of primary traffic, control, and transmission status data bases

4 Direction and coordination of fault localization and restoral

5 Implementation of directives from higher levels of system control responsibility.

Such functions include modification of routing table, access of common-user facilities, and establishment of thresholds and priorities for restriction of access traffic. Fault isolation and restoral activities are important nodal functions because of the proximity of this element to the transmission equipment. The nodal element responds to directives from higher levels of responsibility. It also preprocesses the primary traffic, control and transmission status data base for reports to the higher system control levels.

1.2.1.5 Station Level System Control Functions

Station level system control functions involve equipment and channel status monitoring, maintenance, and restoration. Primary station level functions are:

1 Equipment and channel status monitoring

2 Restorative and preventive maintenance

3 Equipment fault isolation and restoral

4 Primary traffic and equipment data elements monitoring, with data base transmittal to nodal element

5 Implementation of directives from nodal system control elements

6 Interface with common-user facilities.

Many fault isolation/restoral functions (such as hot standby insertion or diversity channel switching) are automatically performed as part of station equipment. Traffic control is affected at the station level by subscriber restrictions that respond to current traffic demand and preestablished

thresholds. Routing table updates are made in response to nodal element directives.

1.2.1.6 Data Collection and Management Subsystems

The realization of integrated system control and management requires a complex and coordinated data system subnetwork distributed among the hierarchical elements of the worldwide Defense Communications System. The accrued data base must be accessible upward in the hierarchy for purposes of intralevel coordination and for long-term management evaluation and planning. It must be available locally for warning and alarming of trouble conditions and for use in deriving alternatives or local control actions to relieve these trouble conditions. It may be accessible laterally for limited intralevel coordination. Automatic Technical Control (ATEC), Traffic Data Collection System (TDCS), and Automatic Central Alarm System (ACAS) are included in the near-term DCS system control structure as special monitoring, data collection, and processing elements. These subsystems are briefly considered in the following subsections.

1.2.1.6.1 Automatic Technical Control (ATEC)

The ATEC equipment provides automated assistance to the technical controller in performance of basic operating and maintenance activities. ATEC primarily supports transmission system maintenance activities through data acquisition, performance monitoring, and analysis. ATEC processors at the sector and nodal level will provide additional capability for automation of transmission, traffic, and network control functions. The prototype ATEC equipment is currently beginning low rate initial production. Presently the ATEC system is composed of a number of modular elements making up a Measurement Acquisition Subsystem (MAS). The in-service monitoring set scans voice channels while in operation and measures such parameters as signal power and noise. The out-of-service monitoring set makes channel performance measurements that normally require circuit interruption. A separate in-service monitoring set is the wideband digital test set which allows detailed analysis of digital multiplex bit streams. The DC monitoring set scans digital channels while in service and measures parameters such as average and peak distortion and baud rate. An alarm reporting set provides the capability for remote scanning of equipment alarms and control relay status. Frequency division multiplex (FDM) baseband signal performance monitoring is performed by the baseband monitoring set which can extract voice channel signals for analysis, conduct baseband spectral analyses, and inject test tones in the baseband. Operational control of the ATEC elements in a particular geographical area is performed by a Node Control Subsystem (NCS) in which are embodied certain system control and management information functions. Coordination between Node Control Subsystems is performed by the Sector Control Subsystem located at a Facility Control Office.

1.2.1.6.2 Traffic Data Collection System (TDCS)

The current TDCS concept provides for automatic acquisition, formating, and transmission of traffic data from the AUTOVON switches to the appropriate ACOC on a scheduled basis. Additional functions include rapid

switch memory reload, memory update, and acquisition of short term traffic statistics summaries. Present monitoring tools such as electromechanical peg count meters, memory peg count registers, traffic usage recorders (TURs), and service observing sets are inadequate (too slow, inaccurate, incomplete) to perform effective network management and planning functions. Meter readings are manually recorded and mailed to DCA headquarters. Memory register counts are output to punched cards and transmitted to headquarters via AUTODIN for processing. TDCS provides the means for automatically collecting traffic data at scheduled 60 minute intervals for up to 2000 items of usage, duration, and count data. Special data reports may also be generated and consist of 20 data items selected from the overall 2000 items. These reports are collected over 15 minute periods and are transmitted via AUTOVON to the ACOC and may be used in implementing network con' actions. Data that may be collected on individual calls include:

1 Originating trunk group and trunk

2 Terminating trunk group and trunk

3 Called number

4 Route digit

5 Precedence digit

6 Final switch matrix connection time

7 Originating trunk release time

8 Four-wire circuit usage time (between switch and ACOC).

Of prime importance is the capability for rapid switch memory reload. Loss of switch memory occurs at a switch on the average of once every 24 hours and must be restored from punched cards, resulting in an average of 10 to 30 minutes of switch downtime. The rapid memory reload function provides for reentry of switch memory data from magnetic tape upon operator request.

1.2.1.6.3 Automatic Central Alarm System (ACAS)

The ACAS provides near real-time indicators for network equipment status monitoring. It automatically scans and senses specific alarm or status indicators at each AUTOVON switch and codes the indicators for transmission to an ACOC for update of a display board and stripchart recording of selected data. Sensing is accomplished using either threshold detection for a cumulative count of a change in a two-state condition for a predetermined number of points, or detection of a change in a two-state condition of a single point. The display provides ACOC controllers with an indication of AUTOVON switch traffic flow, trunk group status, and availability of critical common equipment. The strip display for each AUTOVON switch controlled by the ACOC contains the switch cluster display, the out-of-service common equipment display, and trunk status display. The switch cluster display reflects both interswitch and intraswitch traffic. The component out-of-service display reflects

availability of critical common equipment such as register sender junctors (RSJ), multifrequency transceivers (MFX), and touch call receivers (TCR). It also indicates availability of specific markers, logic, and memory. Failure of logic systems clock and logic comparison function is also indicated; if "A" logic system fails, no traffic data can be obtained from the switch and if the logic clock fails, additional calls cannot be processed at the switch. The trunk status display indicates all trunks busy (ATB) and pilot make busy (PMB) alarms. ATB alarms indicate 100 percent utilization of voice and special grade interswitch trunk groups. PMB alarms monitor those trunk groups by using a carrier system with a group pilot. One PMB alarm indicates a failure in one transmission direction, and two related alarms at interconnected switches indicate failure in both directions of transmission. When both ATB and PMB alarms are present, a carrier is the cause of the ATB condition rather than heavy traffic.

1.2.1.7 Defense Satellite Communications System (DSCS) and Real-Time Adaptive Control (RTAC)

The primary functions associated with the real-time adaptive control of the DSCS are considered in the following subsections. The hierarchical control structure of the DSCS includes a worldwide element composed of the Operations Control Element (OCE), Network Control Elements (NCE), and Terminal Control Elements (TCE). Projected interaction with DCS system control is included in the following discussions.

1.2.1.7.1 Worldwide Real-Time Adaptive Control (RTAC) Functions

The Operations Control Element (OCE) of the DSCS-RTAC is responsible for worldwide management functions similar to that of the DCAOC. OCE functions include trend analysis, contingency planning, long range circuit planning, and allocation of excess capacity to non-DCS subscribers. Typical OCE functions include:

1 Management and planning on worldwide basis

2 Coordination with DCAOC

3 Network level performance and status monitoring

4 Near real-time contigency circuit planning

5 Allocation of excess DSCS capacity to non-DCS subscribers.

An important function of the DSCS in the integrated system control structure will be its co-planning activities with the DCAOC. The OCE also may be called upon to settle intersatellite conflicts in near real time.

1.2.1.7.2 Satellite Level RTAC Functions

The satellite level RTAC element is the Network Control Element (NCE). The NCE is the highest level RTAC element with major real-time control responsibilities and is directly associated with a single active DSCS satellite. Real-time control functions involving both satellite and earth terminal operations are summarized as follows:

1 Real-time satellite operation

a Satellite signal monitoring

b Power/attitude control

c Jamming detection

2 Earth station operations

a Demand access allocation

b Terminal and user monitoring

c Power and time slot monitoring

d Terminal and network fault isolation

e Coordination of circuit planning with ACOCs.

Satellite operations include positional and power monitoring and control, signal monitoring, and jamming detection. Earth terminal operations include network and circuit configuration, power and time allocations, terminal and network status monitoring, and fault isolation. Demand access assignment and cooperative interface with ACOCs within the satellite coverage are also crucial NCE real-time functions. The NCE must be able to provide effective real-time satellite management in both normal and stressed situations.

1.2.1.7.3 Terminal Level RTAC Functions

The Terminal Control Element (TCE) functions involve real-time equipment maintenance and circuit management. The TCE is directly responsive to the NCE for circuit configuration, and directly reports to the NCE regarding channel and equipment status. The TCE also provides transmission interface with other DCS subsystems. Summarized, TCE functions are:

1 Channel quality and status monitoring

2 Equipment status monitoring/fault

3 Channel/multiplex reconfiguration under direction of NCE

4 Coordination with accessing DCS facilities.

1.2.1.8 DCS Digital Upgrade - DEB

The introduction of long-haul digital transmission systems into the global DCS network is being accomplished in discrete phases by utilizing existing and planned digital multiplex and radio equipment as replacements for the present FDM terminals. Performance monitoring equipment is being developed that can automatically detect and report the status of the planned manned and unmanned data terminals.

A pilot program to determine the feasibility of replacing the primarily FDM transmission facilities with digital facilities is implemented in the Frankfurt-Koenigstuhl-Vahingen (FKV) transmission link. Operational characteristic data will be accumulated from this project to be used in the development of standards and criteria for the future upgrade of other long-haul European transmission systems. The FKV project is implemented using a modified Vicom D2 (CY-104) for first-level analog-to-PCM conversion, a second-level Vicom TDM, T1-4000 with Vicom 4030 hot-standby switch protection, a Vicom T1-WB1 wideband data terminal, and a Collins Radio AN/FRC-162 transmission facility.

Further upgrade of the European DCS network will be implemented under the Digital European Backbone (DEB) program, the first phase of which will utilize the same digital equipment as the FKV project. Future upgrade of the DEB system involves the use of the DRAMA equipment consisting of the TD-1192 first-level PCM multiplexer, TD-1193 second-level TDM, and AN/FRC-163 radio set. These would be used instead of the CY-104, T1-4000, and AN/FRC-162 employed in the present upgrade.

Of particular interest to DCS system control are the improved status monitoring, fault isolation, and control capabilities inherent with digital modulation techniques. The inherent capabilities of the digital signal processors is further enhanced by their similarity and compatibility with digital computers.

1.2.2 Information Flow Concept

Reliable and efficient exchange of information among the various levels in the system control hierarchy is a prerequisite for effective control of the DCS. In this section an overall information flow concept for the near-term DCS is outlined that relates to the primary functions of the worldwide, theater, sector, node, and station system control hierarchy discussed in section 1.2.1. This information flow concept has been used to identify potential near-term system control limitations and to recommend near-term DCS upgrades (see section 1.2.4).

The flow of system control information from the station level to higher system control levels is depicted in Figure 1. Indicated in the figure are certain functions performed at each system control level on specific types of information. The forward (F) function indicates that the information is passed to the next level in the received format. Information passed to higher levels in the report (R) function, however, is modified by being

consolidated with other information, processed and refined, and/or reformated by automatic, semiautomatic, or manual methods. The monitor (M) function designates information that is monitored by a network controller and/or processor. Information is stored (S) automatically on disc, tape or printer, or recorded manually by operating personnel. The process (P) function indicates automatic data processing is performed on the information for fault isolation, status summaries, or trending analysis. Automatic or manual analysis of information is indicated by (A), and information utilized for fault isolation purposes is indicated by (I).

Figure 2 illustrates the flow of information from the higher levels of the DCS system control hierarchy. This information consists primarily of directives, requests for data, network configuration data, and fault assessment data. The forward (F), store (S), and process (P) functions are the same as those indicated in Figure 1. The directive (D) implementation function designates the level at which operational direction messages or requests for data are executed.

1.2.3 Network Controller Responsibilities and Functions

The Senior Network Controller (SNC) at the ACOC plays a vital role in the operation of the Defense Communication System. He must know at all times the real-time status of designated communications systems under his supervision. When a situation occurs that results in degradation or loss of service to users of the DCS, he must take near real-time action to restore service to users by any available means in accordance with established restoration priorities. To satisfy these responsibilities, the SNC must perform specific daily functions related to technical direction, coordination, technical supervision, restoral, fault isolation, status monitoring and status reporting, as outlined in Table 1. To perform these functions, the SNC must:

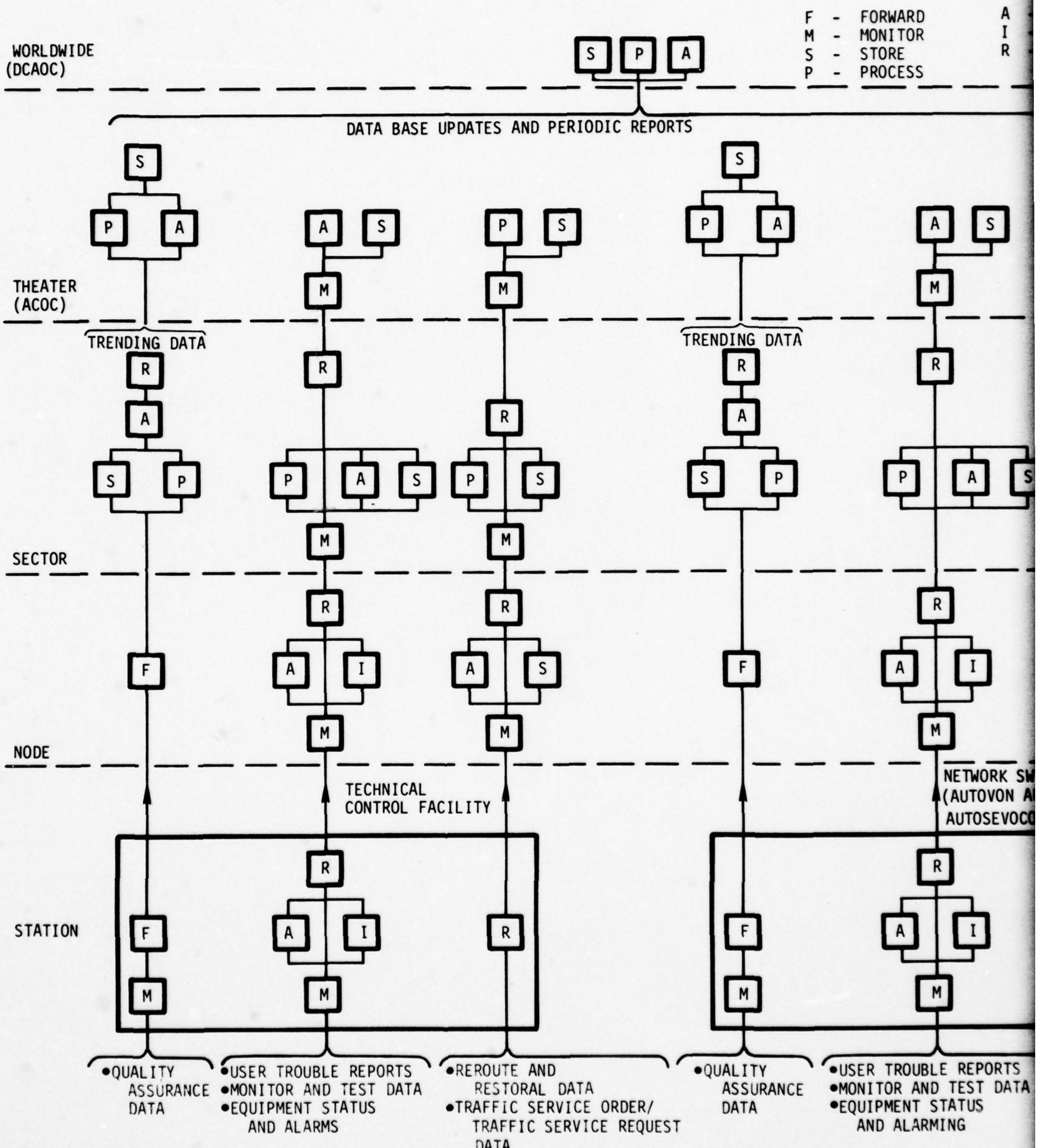
1 Collect status information via orderwire and critical control circuits

a Monitor network performance via M-40 terminal (performance indices, data base alarms)

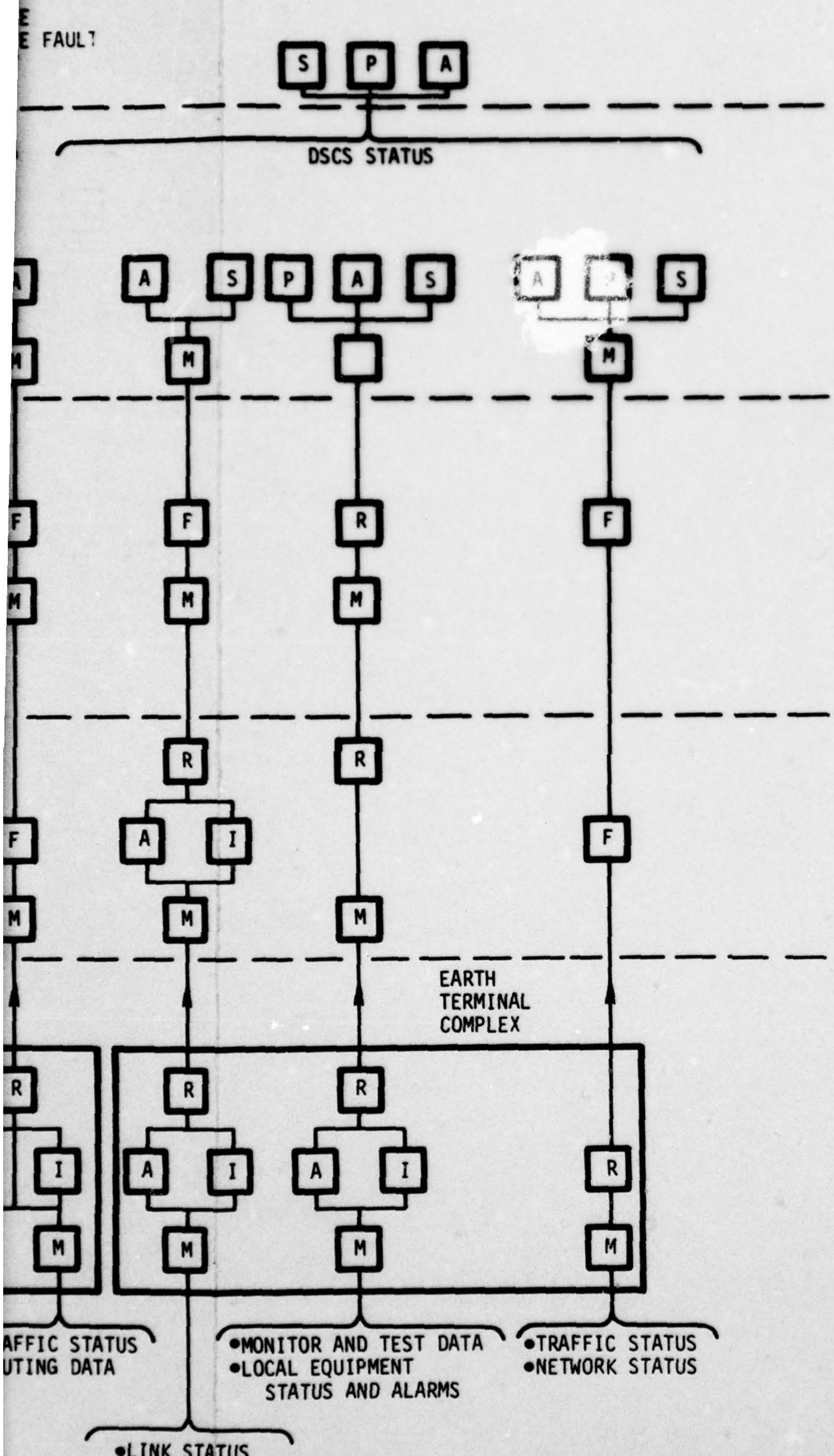
b Use data switching terminal (DST) to interface, via orderwires, with switches

c Utilize processor equipments, input and output writers, control consoles, and electromechanical displays to obtain status information

d Receive status of transmission links, supergroups, groups, channels, and circuits for operational direction, management, and record purposes.



F - FORWARD
M - MONITOR
S - STORE
P - PROCESS
A
I
R
WORLDWIDE (DCAOC)
DATA BASE UPDATES AND PERIODIC REPORTS
THEATER (ACOC)
TRENDING DATA
SECTOR
NODE
TECHNICAL CONTROL FACILITY
NETWORK SW
(AUTOVON A
AUTOSEVOCO
STATION
•QUALITY ASSURANCE DATA
•USER TROUBLE REPORTS
•MONITOR AND TEST DATA
•EQUIPMENT STATUS AND ALARMS
•REROUTE AND RESTORAL DATA
•TRAFFIC SERVICE ORDER/ TRAFFIC SERVICE REQUEST DATA
•QUALITY ASSURANCE DATA
•USER TROUBLE REPORTS
•MONITOR AND TEST DATA
•EQUIPMENT STATUS AND ALARMING



ure 1. Information Flow from Station Level to Higher Levels

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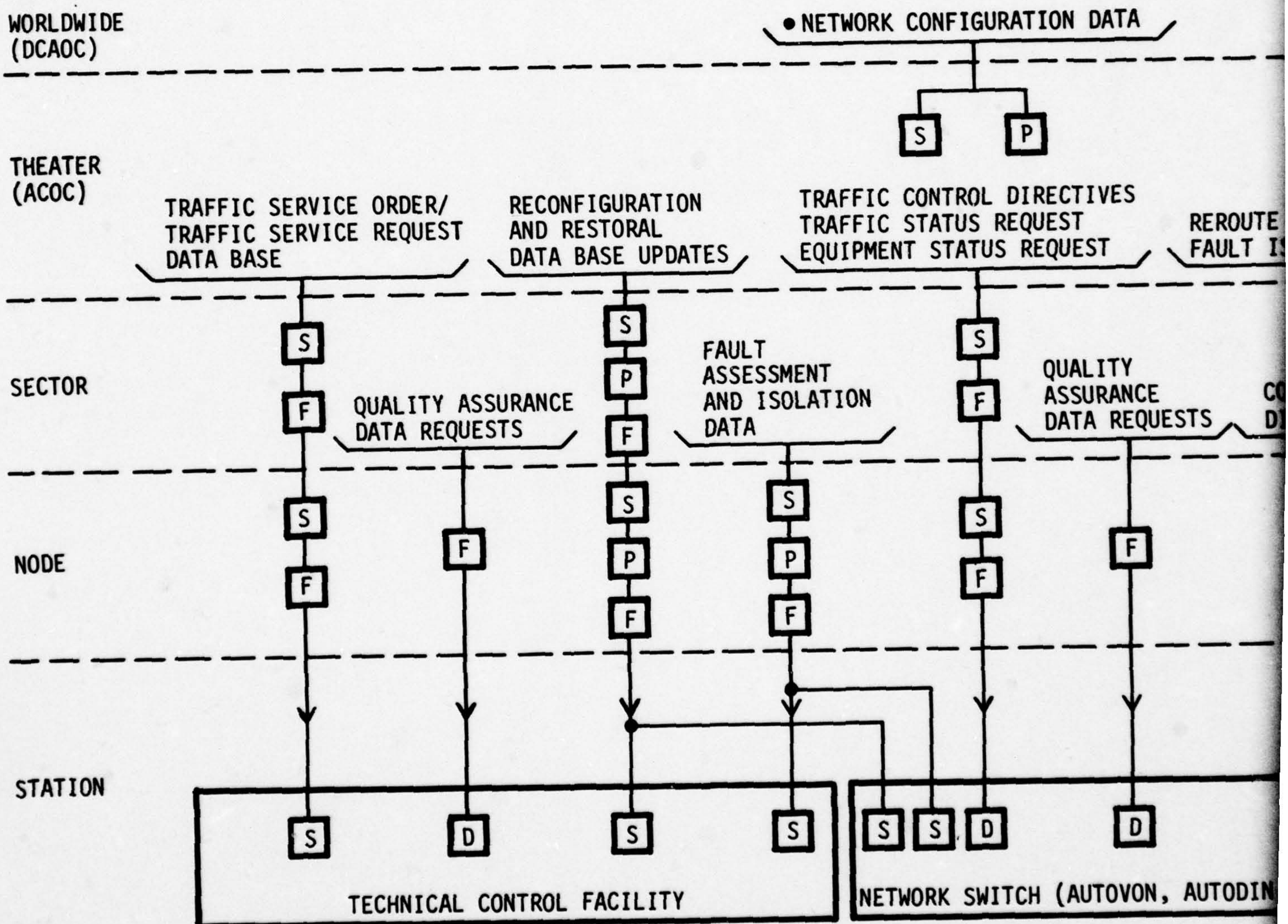

WORLDWIDE (DCAOC)
THEATER (ACOC)
SECTOR
NODE
STATION
NETWORK CONFIGURATION DATA
TRAFFIC SERVICE ORDER/ TRAFFIC SERVICE REQUEST DATA BASE
RECONFIGURATION AND RESTORAL DATA BASE UPDATES
TRAFFIC CONTROL DIRECTIVES TRAFFIC STATUS REQUEST EQUIPMENT STATUS REQUEST
QUALITY ASSURANCE DATA REQUESTS
FAULT ASSESSMENT AND ISOLATION DATA
QUALITY ASSURANCE DATA REQUESTS
S
P
F
D
TECHNICAL CONTROL FACILITY

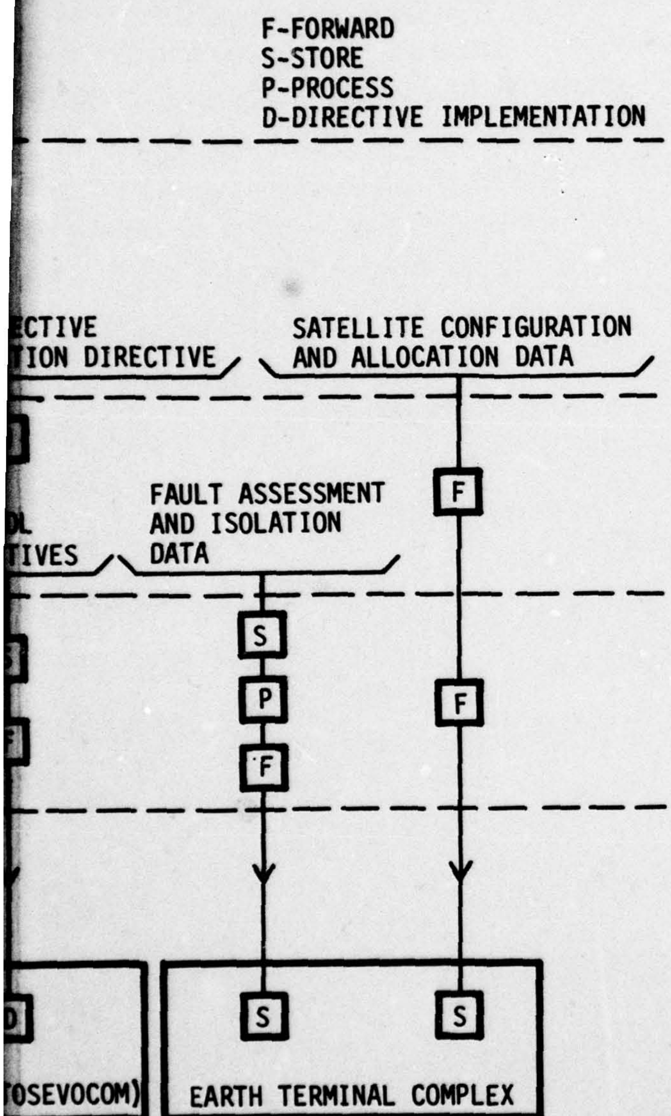

Figure 2. Information Flow to Lower Levels

2

TABLE 1. ACOC SENIOR NETWORK CONTROLLER FUNCTIONS

1 Maintain configuration of switched network.

- a Specify network/transmission configurations.
  - 1) Specify activation, rearrangement, and deactivation of transmission links, supergroups, groups and channels (including preactivation circuit conditioning, testing, and reporting).
- b Maintain inventory on location, use, and status of switched network resources.
  - 1) Advise appropriate agencies and control levels of operational status of assigned facilities and systems.
  - 2) Maintain continuous knowledge of facilities available for rerouting.
- c Supervise addition, deletion, or restoral of switches.
- d Determine required user service.

2 Oversee network traffic control operations.

- a Coordinate changes in transmission system in response to adverse traffic data and facility disturbances.
- b Coordinate control actions affecting theater and intersector areas, including specified services to designated users.
  - 1) Monitor, supervise, and direct restoral and reroute actions within the theater in accordance with centralized restoral plans.
  - 2) Monitor, supervise, and direct timely actions to correct degradations that affect facility and system performance and user service within the theater.
  - 3) Coordinate control actions affecting AUTOVON, AUTODIN, and DSCS.
  - 4) Coordinate with local facilities and other ACOCs to isolate and correct intertheater transmission link problems.
- c Direct control actions of subordinate areas (sector levels).
- d Exercise control of theater level transmission systems.
- e Authorize and approve activation and deactivation of traffic overload circuits.

3 Monitor, maintain, and analyze real-time status of stations, systems, and trouble reports under controller's cognizance.

- a Supervise accumulation of traffic and performance data for long term planning.
- b Advise commands/agencies of serious disruptions to their communications capabilities.
- c Maintain required logs and records and provide data for preparation of pertinent reports.

4 Supervise network fault detection, isolation, and restoral.

- a Coordinate fault localization within multiple link configurations.
- b Coordinate substitution of equipment or channels as necessary for maintenance, isolation of communications faults, or restoral of user service.
- c Monitor network to assure effectiveness of corrective actions taken.
- d Compile information and make recommendations regarding equipment malfunctions and service interruptions.

5 Resolve conflicting inter-area decisions.

6 Schedule operations and maintenance activities for AUTOVON and AUTODIN.

7 Supervise overall operation of the ACOC.

2 Analyze status information and make control decisions.

3 Issue operational directives via orderwire and critical control circuits

a Issue operational direction messages (ODM) - message or telephone instructions - to direct actions or request additional information

b Follow up verbal ODM with record ODM within 24 hours

c Initiate instructions to DCS station commanders to ensure ODMs are brought to the attention of the appropriate element.

1.2.4 Near-Term DCS Upgrades

This section presents recommended upgrades to the near-term DCS that reflect necessary requirements for effective near-term system control. These recommendations are based upon study and analysis of the near-term DCS configuration, information flow requirements, and controller functions discussed in previous sections of this report. Recommendations are presented in categories as related to TDCS, data base, and controller aids.

In general, data processing in the DCS system control hierarchy should be maximized at each level, and only pertinent system control and management data necessary for real-time control, restoral, and reallocation of resources should be forwarded to higher levels. Long-term planning information should continue to be mailed or transmitted on an as available basis via AUTODIN. The DCAOC should continue to function as a nonreal-time control level, and only in an extreme crisis or emergency should it become involved in day-to-day traffic and network problems. One possible exception to this policy would be in the initiation of alternative contingency plans via AUTOVON in special situations.

1.2.4.1 TDCS Recommendations

As the TDCS is the primary real-time traffic data acquisition element in the DCS, it should be utilized to a greater extent in maintaining the system control data base. Currently the traffic data accumulated by the TDCS is seldom used in real-time system control decision making. Other than rapid memory reload (RMR), the TDCS does very little to aid the system control process other than provide management and planning data more accurately than previous switch peg count and metering and manual recording methods. With the implementation of a controller interactive interface with the TDCS processor via the the Computer Assisted Display System (CADS) or minicomputer, more effective use of the TDCS system can be achieved.

An evident shortcoming of the TDCS is its lack of flexibility in the gathering of real-time data. A multiplex function should be implemented for system control so that data from more than on switch can be requested simul-

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taneously by the ACOC. This multiplexed data gathering function would alleviate the difficulty in obtaining special request data periodically. Another TDCS shortcoming is that data is not stored in a form readily accessible by a processor for performance of data base analysis for system control functions.

To make TDCS more useful for system control, restoral, and reallocation functions, the current software must be updated to allow priorities to be set for acquisition of traffic data, to allow for periodic reporting of traffic data on a continuous basis, to forward the periodic reports to the ACOC for data base updates, and to allow for convenient changes to the list of parameters in the periodic reports. Also, it should not be required that a long report be in progress from a switch to make a special request measurement.

1.2.4.2 Data Base Recommendations

In the performance of system control, restoral, and reconfiguration functions in the near-term DCS, acquisition of more data than required to carry out these functions is as cumbersome as not having enough data. Unnecessary data acquisition unduly burdens the processors at the various levels and the transmission facilities, as well as the operating personnel. A detailed assessment of the entire DCS data acquisition and reporting system should be made to optimize data acquisition and eliminate nonessential data. Dedicated special grade lines should be used for data acquisition (and issuance of operational directive messages) with provision for changeover to switched lines if a dedicated line failure occurs. The transmission rate on dedicated data acquisition lines should be 4800 baud, with the capability of switching to lower baud rates if necessary for transmission over degraded lines. The ACOC has the responsibility of maintaining a complete data base for all facilities in its assigned area, and oversees all control, restoral, and reconfiguration functions. The sector maintains a data base for its assigned area and directs routing changes. It assumes responsibility for issuing system control directives when communication with the ACOC has failed. The nodal element maintains a data base for stations and equipment under its responsibility and originates control directives only when communication with the sector has failed. The station level maintains a data base only for restoral of hardware under its jurisdiction.

As discussed in section 1.2.4.1, TDCS currently does not maintain an adequate data base at the ACOC to allow performance of fundamental network control functions. With the update to TDCS software previously discussed and the incorporation of ACAS and ATEC data into a data base accessible by processors at the ACOC, the primary functions of system control, restoral, and reallocation can be performed at the ACOC on a near real-time basis.

1.2.4.3 Controller Aid Recommendations

Interface of the network controller with the network data base is accomplished via the CADS or minicomputer. It is essential that the system controller be provided computer-aided assessments of network performance and a menu of controls and directives which may be initiated via

terminal keyboard or light pen. Using automatic or semiautomatic fault isolation techniques a combination of controls and directives based on traffic, call, and network data can be presented to the controller for implementation. At each level in the DCS, specific menu options can be presented to the controller that are dependent on their system control responsibility in the network. A specific example for use of menu options is in the Inform System utilized for transmission of short messages via teletype or CRT. Current procedures require that a separate operating manual be referred to for information on message formats and destination codes. An interactive menu can be used to allow use of the Inform System without reference to a separate manual.

Of crucial importance in the controller/data base interface are displays that convey meaningful information in an effective manner. Such displays may combine several measurements to provide the controller with a quick look at network resources and traffic situations in near real-time. Several of these displays have been developed and are discussed in section 1.3. An essential part of this display system is a smart terminal with graphics capability which could use the CADS system interface to access the data base (also discussed in section 1.3). A specific example of the use of this display system is in the ACOC SPOT procedures. Currently a link or station outage is indicated by a 27-character alphanumeric message that must be decoded by the controller. The use of a topological display of network status (section 1.3) will greatly enhance the system controller functions.

At the ACOC another controller aid which would greatly enhance the performance of network control activities would be a network simulator running in parallel with actual network operation. The simulator would allow trial of system control techniques on a noninterfering basis with the network, and would also serve as a valuable training aid for ACOC and sector controllers in acquainting them with network control techniques and typical network responses.

1.3 Controller Aids and Data Base Requirements

Numerous controller position displays and formats have been considered to aid DCS network controllers in achieving timely system diagnosis and control implementation. Effective controller displays require elimination of nonessential data and/or emphasis of critical data. To ensure that these goals may be realized, it is imperative that the controller has some capability to format displays dynamically. This capability simply may be to limit displays to a given sector or sectors that exhibit potential disturbances, and thus eliminate extraneous data from other sectors that display normal behavior. Similarly, a single node with detailed trunk group status may be desired for display. Overlay formatting is another means of allowing controller display flexibility. The controller may request specific detailed information to be overlaid on an existing diagram. This information may include trunk group designation, occupancy status, GOS status, or directional flow patterns that the controller could successively or simultaneously overlay on a topological diagram of the network or subnetwork.

Threshold type alarm indicators help to draw controller attention to critical data by emphasizing potential problem areas. This emphasis also aids in correlation of observed data for timely isolation of the real problem. With nonuniform traffic patterns, such as exhibited by the European AUTOVON with CONUS, it is important that alarm thresholds be set to reflect excursions from normal behavior. European gateway links to CONUS, for example, have a normally high blocking rate, so that higher threshold values for GOS status must be set. That is, alarms should indicate potential or actual abnormality. In fact, the significance of specific thresholds will vary according to time of day (busy hour versus nonbusy hour) or according to recognized network degradations. Once a fault is indicated and interim action taken, it may be desirable to raise certain thresholds to reflect the expected interim status.

Graphical displays provide a means of presenting significant amounts of data in a form easily digested by the human controller. For efficient and flexible graphical presentations, however, visual display units (VDU) with special capabilities are desirable. First, the VDU should be capable of drawing lines anywhere and at any angle. Those terminals that provide graphics through specially defined alphanumeric characters are generally quite limited in this capability. True graphic terminals generally allow excitation of any of the n*m points that define the overall picture.

Also desirable is a graphical overlay capability. For example, a grid and axis may be drawn and annotated as a background. Subsequently, various curves may be sequentially drawn, viewed, and removed without the background being regenerated. In a network topology overlay, link GOS figures may be periodically computed and new values can replace old ones overlaid on the VDU. This permits dynamic monitoring of network status. This type of overlay capability requires a VDU with a point-by-point memory periodically accessed to refresh the visual display (usually several times a second). Data may be dynamically updated by selectively altering portions of the point-by-point memory.

The flexibility, ease of update, and CPU requirements are further improved by having a smart terminal, that is, one with some processing capability and, perhaps, additional memory capability of its own. Smart terminals range from the very limited to the very sophisticated. The Tektronix 4010, which accepts either vector graphic or alphanumeric data, internally converting to a dot matrix on the screen, is a very limited smart terminal. The 4010 has no refresh memory, so dynamic overlay capability is very limited. Other terminals are in themselves minicomputer based, so all formatting may be accomplished by the terminal. The host computer/VDU data transfer is bilateral and rapid. The VDU computer processing controller inputs and requests the required data base elements through computer-to-computer interface. With this level of smart terminal, very sophisticated interactive and dynamic displays may be presented with almost no burden on the host computer.

An additional level of color VDU is also available. The refresh memory point is a color-encoded byte. The principal disadvantages of color VDUs

are cost and programming complexity. However, color is an extremely effective way of displaying time-varying flow and status characteristics. The use of color encoded controller displays is not discussed further in this report, but the subject does deserve extended consideration.

The following subsections discuss several candidates for controller position displays that require various degrees of noncolor VDU sophistication. While specific controller aid displays are illustrated, the formats are readily adaptable to various data types at all system control levels. Alarm emphasis, bar chart, and topological overlay formats are considered in particular.

1.3.1 Alarm Isolation Displays

As previously discussed, exclusion of excess data and emphasis of critical items are important criteria for effective controller aids. Figure 3 illustrates a potential option for display of link status that meets these criteria. Only alarmed states (or, optimally, states at and above a specific alarm level) are displayed. Nonalarm states are excluded. Potential trouble spots are highlighted by the multilevel alarm indications, and such indicators may often be sufficient to direct the controller to subsequent displays or decisions. Supporting data are presented should the controller require additional data to isolate problem causes such as abnormal traffic demands or loss of capacity. Such displays require only alphanumeric display, the simplest of VDU terminal capabilities.

Similar formats are applicable to source node and source node to destination node statistics. Link and source node by precedence-level statistics may also be effectively presented in this format. Figure 4, for example, illustrates the presentation of alarmed node GOS status at precedence levels immediate and above. Blockages occurring at the normally nonblocking precedence levels are particularly significant data for fault isolation.

The alarm isolation format has application at nodal and higher levels of the system control hierachy. Figure 5 illustrates potential utilization at ACOC, sector, and nodal levels. The lower level displays are also applicable at the higher level system control stations for detailed inspection of selected regions or nodes.

1.3.2 Bar Chart and Related Displays

The bar chart presentation of link or node status information is an effective medium for emphasizing potential trouble areas in a network or sector. Figure 6 illustrates a link GOS status bar chart that was generated on a large screen oscilloscope. This display was developed under a previous contract with DCEC by a multiplexing scheme implemented on an analog/hybrid computer. Scope updates are rapid compared to associated time constants, so the controller can dynamically view the changing network or regional status.

***** 0:50: 0*****

*ACCUMULATED LINK/PRIORITY GOS STATUS

LINK A	TOTAL BLCK/ATTM=X.XX	P0 BLCK/ATTM	P1 BLCK/ATTM	P2 BLCK/ATTM	P3 BLCK/ATTM	P4 BLCK/ATTM
1**	213/ 326=0.65	0/ 0	3/ 4	113/ 186	62/ 84	35/ 52
3***	205/ 259=0.79	0/ 0	4/ 5	118/ 152	54/ 65	29/ 37
8**	52/ 102=0.51	0/ 0	1/ 4	23/ 54	15/ 25	13/ 19
10***	322/ 322=1.00	0/ 0	0/ 0	119/ 119	90/ 90	113/ 113
14***	344/ 344=1.00	0/ 0	3/ 3	119/ 119	85/ 85	137/ 137
22 *	23/ 67=0.34	0/ 0	1/ 1	0/ 2	8/ 22	14/ 42

Figure 3. Link Status - Alarm Only Display

***** 2: 0: 0*****

ACCUMULATED SOURCE NODE/PRECEDENCE NETWORK STATISTICS

NODE	PREC	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	PREC	NODE
5 *	2	952	4	948	0	0.0042	0.0000	2	5
6 *	2	291	2	289	0	0.0069	0.0000	2	6
17 *	2	329	3	326	0	0.0091	0.0000	2	17
18 *	2	398	2	396	0	0.0050	0.0000	2	18
1 **	3	646	161	485	270	0.2492	0.5567	3	1
2 *	3	243	46	197	81	0.1893	0.4112	3	2
5 ***	3	486	220	266	241	0.4527	0.9060	3	5
6 *	3	423	81	342	103	0.1915	0.3012	3	6
9 *	3	892	91	801	155	0.1020	0.1935	3	9
10 *	3	896	92	804	117	0.1027	0.1455	3	10
17 *	3	286	29	257	41	0.1014	0.1595	3	17
18 *	3	470	63	407	46	0.1340	0.1130	3	18

Figure 4. Node Status - Alarm Only Display for Precedences Immediate and Higher

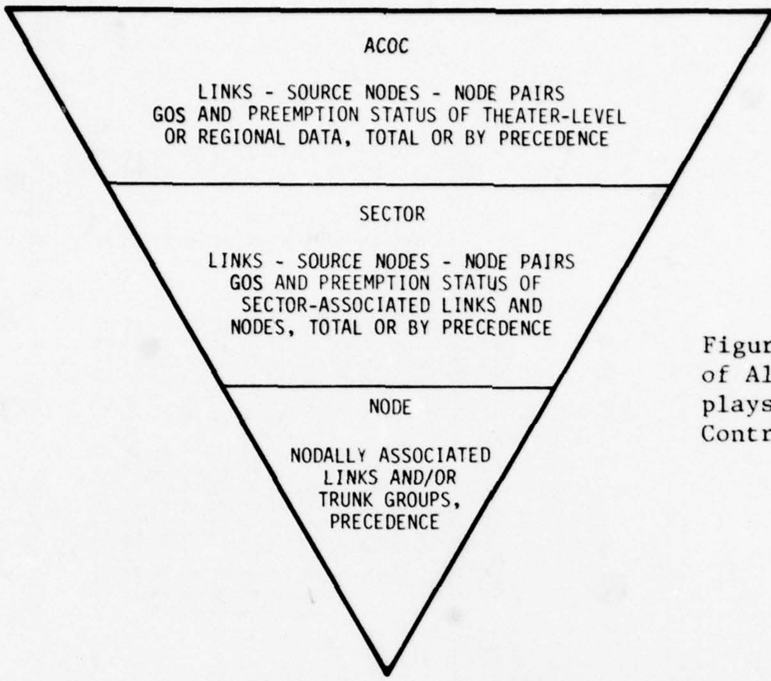


Figure 5. Application of Alarm Isolation Displays at Each System Control Level

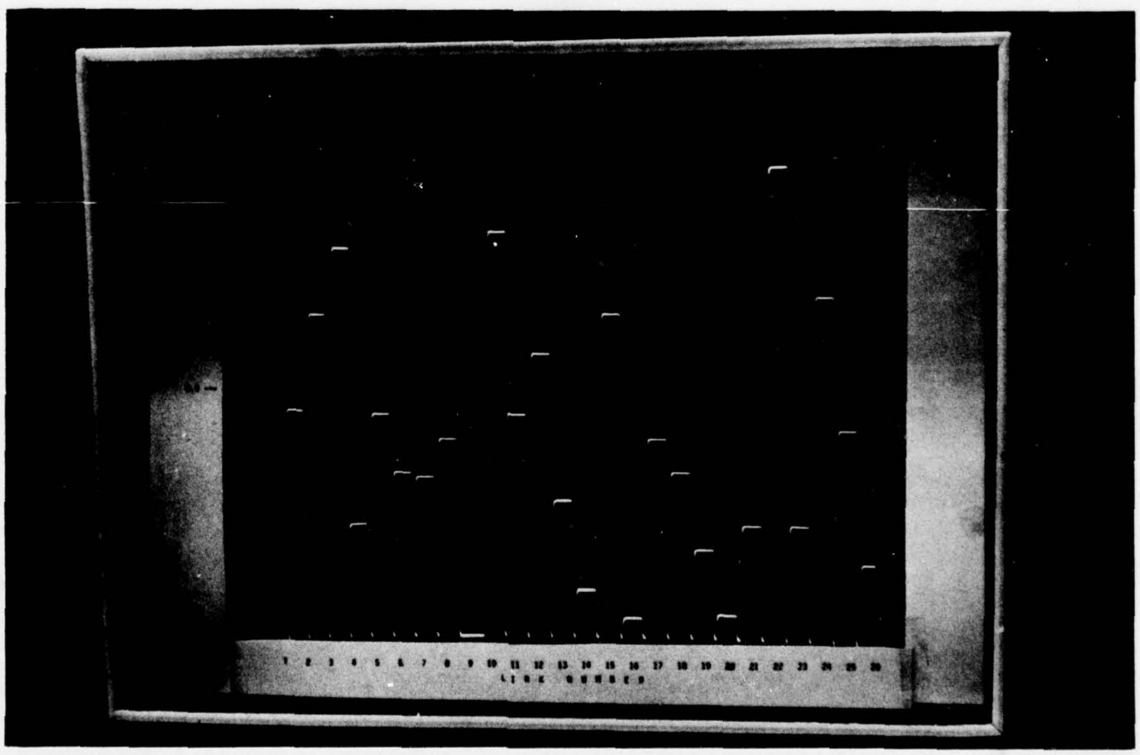


Figure 6. Link GOS Bar Chart Display

Alarm state emphasis (blinking display) and isolation (exclusion of bars for nonalarmed states) also have been implemented as controller selectable options. This type of dynamic display is not feasible with a nonrefreshing VDU since rapid updating is required. Snapshot displays of this type, however, are readily generated on essentially any VDU with vector or even alphanumeric graphic capability. Network data that can be effectively viewed in this manner includes link and source node GOS and preemption statistics.

Link occupancy and percent utilization data (a much faster time constant which definitely requires a refresher VDU) are other potentially effective displays with this format, although the real time occupancy data is not normally available at sector or theater levels. These occupancy displays can be effective at nodes with many connecting links (such as Donnersberg) where relative load levels may help demonstrate origins of overload traffic.

Bar chart presentation of normalized status information is a particularly effective method of emphasizing potential trouble locations. Figure 7 illustrates normalization applied to GOS status of links 1 through 12. The hypothetical link GOS data presented were accumulated over an interval of 1 minute. The vertical axis denotes the expected proportion of samples that should exceed the associated deviation under nominal network operation. For example, link 1 is at a level that is normally exceeded approximately half the time, so that no cause for alarm is indicated. Link 6, however, is at a level normally exceeded only one of every 100 samples, and is potentially a critical link. The illustrated dots are an option that allows some past history information to be presented. Each time the bar chart is updated, the previous bar is replaced by the single dot. Hence, some past history is available for illustrating the distribution of abnormal excusions. If the past history data is presented, however, the controller should be able to delete it at will. If the controller suspects problems with certain facilities, such as with link 6 from Figure 7, additional time history information may be required for proper trending analysis. Figure 8 illustrates one such display. Here past history data is chronolgically presented for links 6 and 7, illustrating a definite trend towards degradation with link 6 and, while not conclusive, indicating that link 7 status may be degrading as a result of link 6 degradation. Such a past history display requires additional storage and processing capability which may impact processor CPU and memory requirements.

The nomalization algorithms also require considerable processor time and/or prestored normalization functions. Of primary difficulty, however, is definition of the normalization algorithms or functions. They will be extremely dependent on the individual network and on the processing interval. Most likely these functions will have to be defined through simulation exercises. Since these functions represent levels of confidence that the observed status depicts normal behavior, these or similar type functions must be determined if the controller is to be able to effectively and timely correlate observed statistical data with potential network problems.

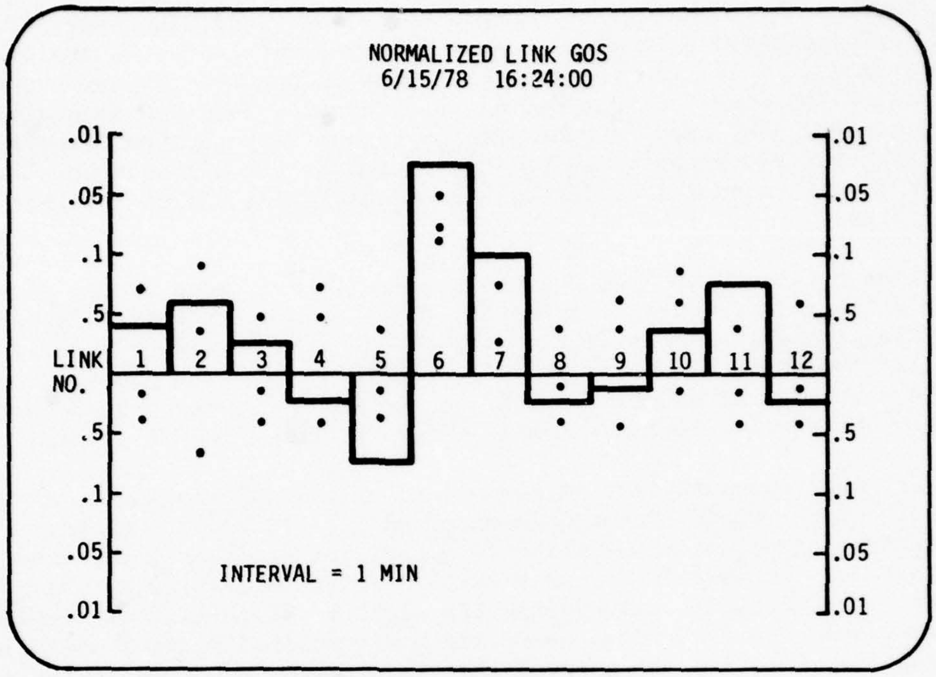


Figure 7. Normalized Link GOS Display

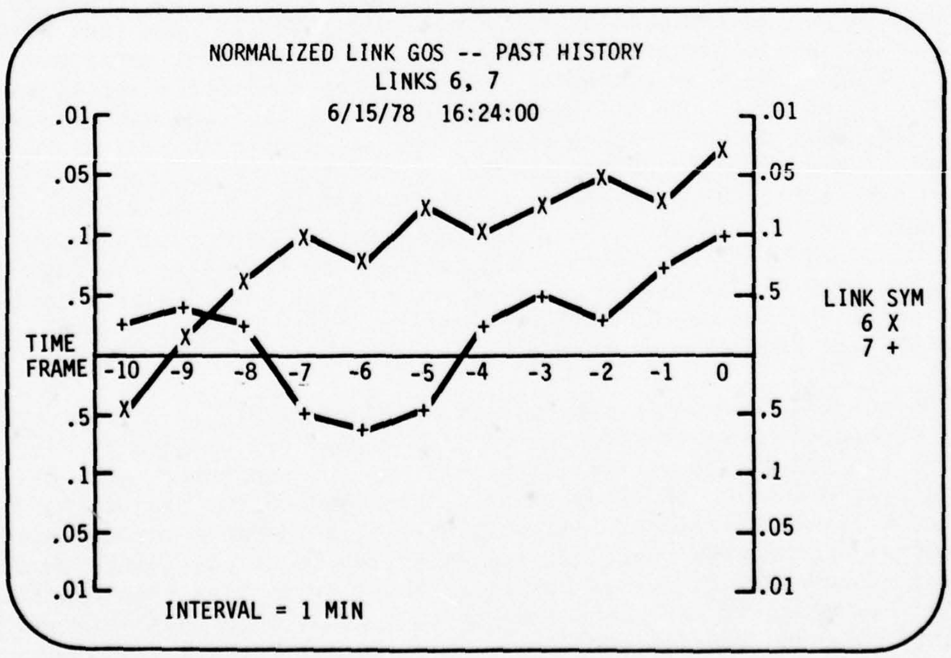


Figure 8. Normalized Past History Status Display

1.3.3 Topological Overlays

Topological displays present a new dimension to controller aids - logical interconnectivity. Typically, stress originating in one portion of a network will cause observed disturbance in other parts. A multitude of alarms often masks the real problem. Topological displays can aid the controller in correlating the stress indicators through recognition of concentrated or interconnected areas of stress.

This section illustrates three topological overlay formats. The first is associated with a regional subnetwork, and is appropriate for sector or theater level control positions. The second is a nodal breakout with particular benefit to the nodal control position. The third is a route tracing overlay that could be benefical at any system control level. Each display illustrated is most effectively implemented within a dynamic format, where specific callouts are periodically updated. Interactive options, where the controller can quickly change the callout (from total link GOS to link GOS at a specific precedence, for example) further enhances the topological format as a controller aid.

Topological displays require considerable software sophistication which may be a burden on the network processor unless such software functions are provided by a smart terminal visual display system. Although snapshot type topological displays have some merit, the dynamic real time overlay updates can present the data in a much more effective manner. Dynamic updates require a refreshing type VDU with a matrix memory. For software development purposes, it is also imperative that the VDU may be addressable in both vector graphics and alphanumeric modes.

Figure 9 illustrates a topological overlay on a regional basis. The background display is the region of Donnersberg, Langerkopf, and Schoenfeld in the European AUTOVON. Link numbers and link GOS figures are presented in the L/GOS format on the clockwise side of each link, while alarm status is indicated on the counterclockwise side. Both GOS and alarm status may be presented dynamically with periodic update.

If smart terminal and dynamic update capability are available, regional traffic flow information may be very efficiently presented through dynamic segmentation of link lines as illustrated in Figure 9. Total link capacity is divided into three segments. The segment closest to each node represents the relative amount of capacity occupied by incoming traffic. The farthest segment represents outgoing traffic, and the central segment represents available capacity. PBX traffic flow to and from the switch are indicated by the bold lines. Additional overlay information that might be requested by the controller includes control status information at displayed links and nodes. This display is most effective if the controller is provided a menu whereby he may interactively request or delete specific information, and thereby design his display to most effectively serve his immediate needs.

Figure 10 illustrates a nodal breakout display with status and flow indication similar to the regional overlay. Link 8 (Hillingdon to Donnersberg) is indicating complete saturation, as only two line segments are shown.

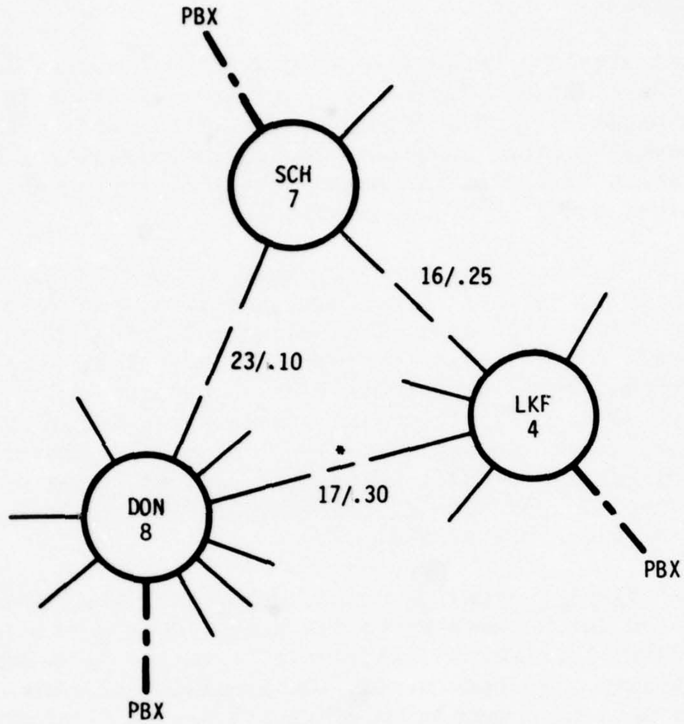


Figure 9. Regional Overlay with Link GOS and Flow

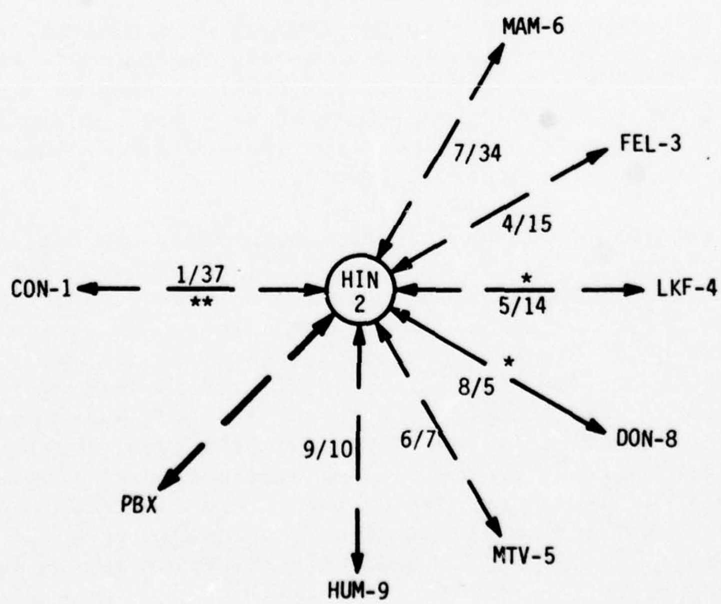


Figure 10. Nodal Display with Status and Flow

This format is particularly useful in isolation of anomalies that generate abnormal traffic flow patterns.

Another potential controller aid is represented in Figure 11 in which background information is the European AUTOVON theater with satellite and terrestrial capacities called out. The operator then requests display of route traces for specific souce/destination nodes, such as for Hillingdon to Humosa in Figure 12. On a dynamic VDU the displayed routes would be flashed for emphasis at a period of about 1 second. Alternately, the controller could step through the routes one at a time to display normal routing sequences. Such displays would assist in the development of alternate routing plans in stressed environments. This display requires either a centralized knowledge of nodal routing tables or route tracing capability through network signalling channels.

It is recommended that regional and sector offices be responsible for maintaining real time routing table information within their respective areas of responsibility, and that this information be made available upon request to lower levels of the system control hierachy. In this manner, a nodal operator could trace routes through his node to various destinations, and could assist in making timely decisions to assure complete logical connectivity in stressed network environments.

1.4 Interactive Network Simulator Scenarios

Overseas AUTOVON baseline scenarios and controller interactive scenarios performed with the interactive network simulator are illustrated in this section and in Appendix C. The controller interactive scenarios depict satellite link reallocation, routing table update, and channel reassignment.

1.4.1 Overseas AUTOVON Baseline Scenario

Baseline runs were made with the interactive network simulator for the Overseas AUTOVON configuration, as illustrated in Figure 13, and described in Appendix B. This baseline series illustrates the typical response of the network over a 2-hour period for busy hour traffic levels, and provides a standard for validation of the network simulator upon incorporation of future modifications. Outputs of the interactive network simulator for the baseline scenario are presented in Appendix C.

1.4.2 Controller Scenarios

Two scenarios in the European theater of operation are presented. Both center about the Feldberg node. Scenario 1 represents failure of the earth station at Feldberg that leaves the corresponding gateway with very limited capacity. Scenario 2 depicts a multiple link failure at Feldberg. Both the Donnersberg/Feldberg and the Langerkopf/Feldberg links suffer complete failure. Logically, particular node pairs are isolated and the call-carrying capacity that connects many of the nonisolated node pairs is considerably reduced. Reallocation of the satellite capacity is used for restoration of

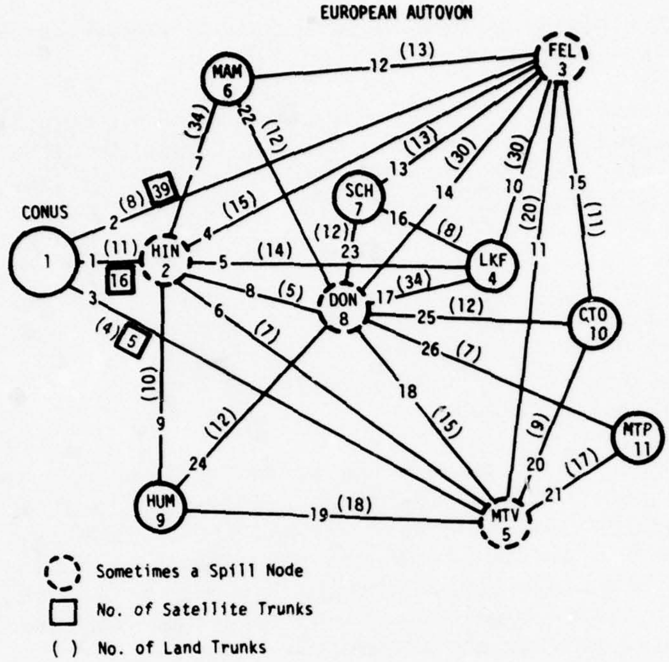


Figure 11. Background Display

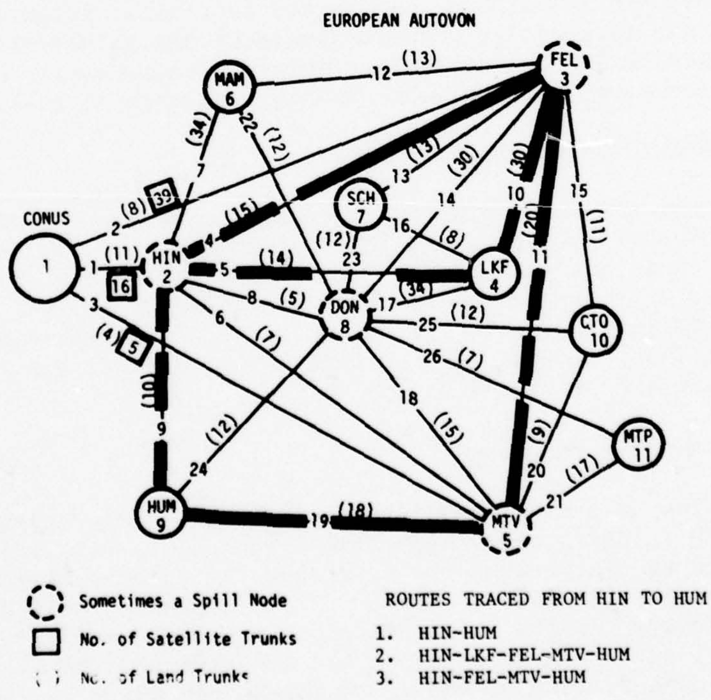


Figure 12. Route Tracing Display

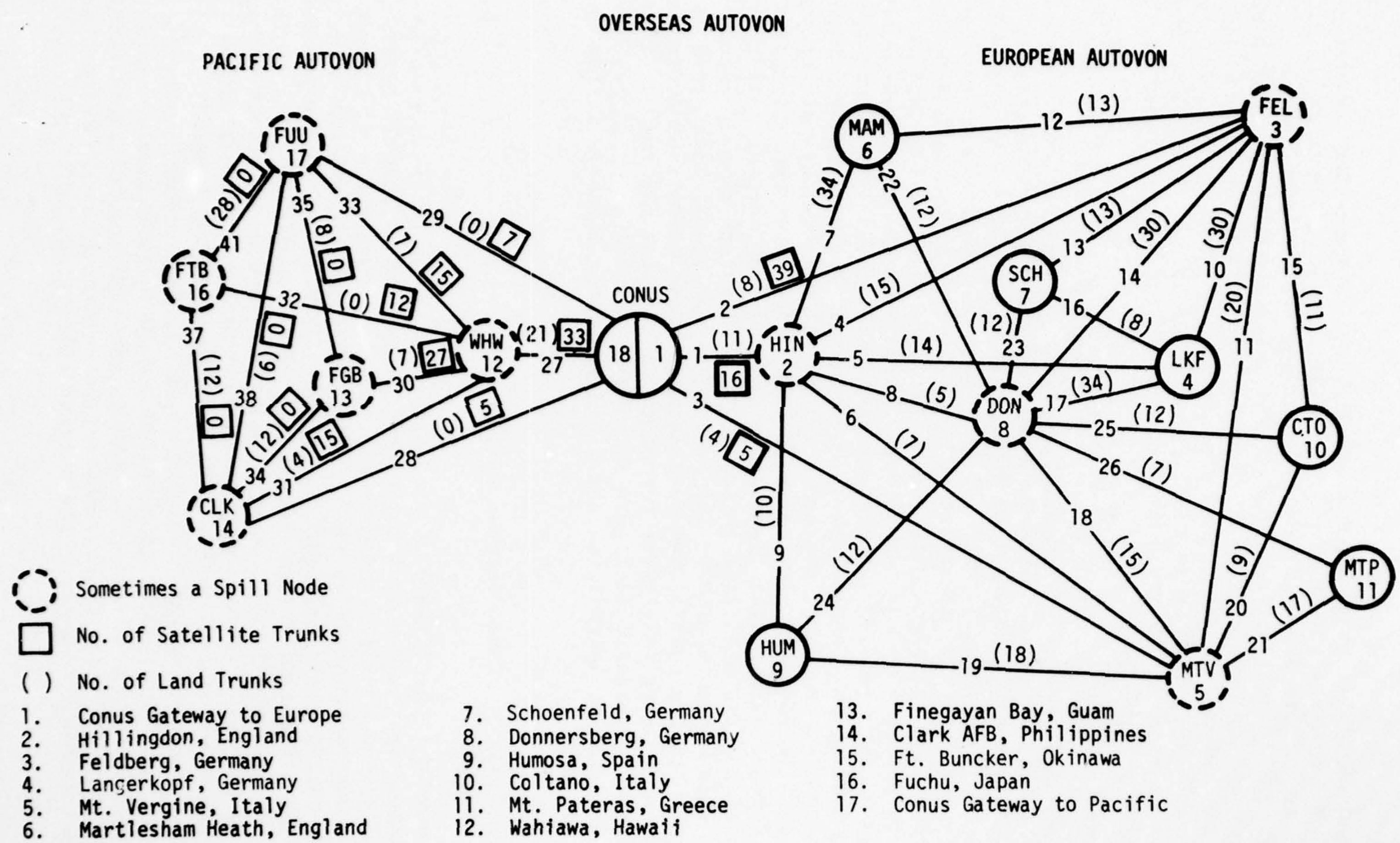


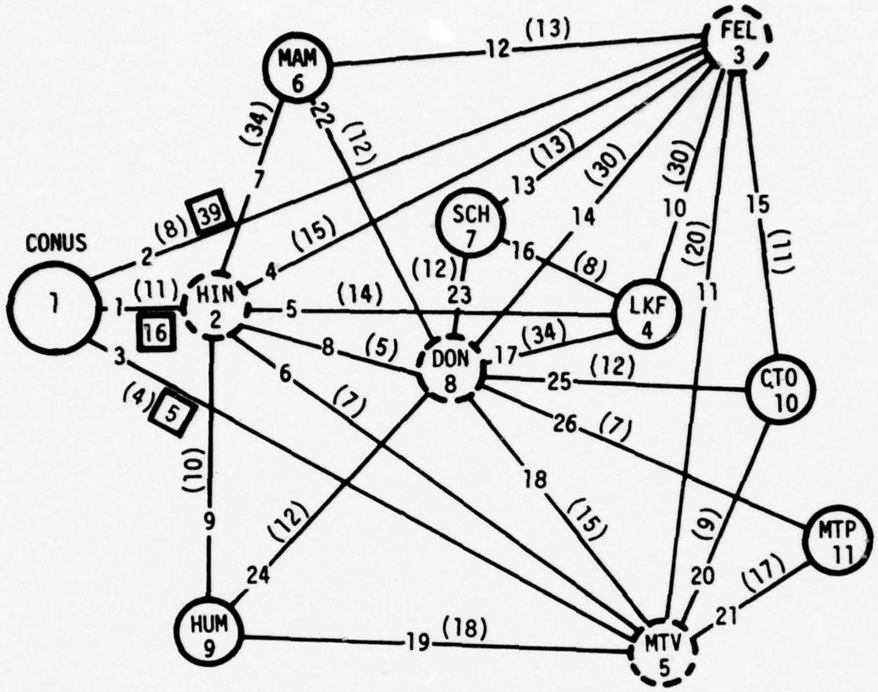
Figure 13. Overseas AUTOVON Configuration

service in Scenario 1, while both alternate routing plans and channel reassignment schemes are considered for interim strategies in Scenario 2. In each case, representative behavior is provided for the normal unperturbed network and for the perturbed network. The behavior improvement that results from the simulated control actions is documented. In all cases, the simulated perturbation occurs at 40 minutes into the run, while restoration of all perturbations and controls occurs at 90 minutes. Each run presents two hours of simulated AUTOVON data. Control actions are implemented 10 minutes after perturbation.

The scenarios were run in a batch mode at 60 times faster than simulated real time to allow concise presentation of the supporting data. In the interactive mode the controller would switch to a real-time mode while attempting to isolate and correct the problems. The supporting data and displays for Scenario 2 demonstrate the process of problem isolation and control design by the interactive controller. Both stripplot and tabular displays are presented. For the stripplot displays, the theater-level and link grades of service displays present data accumulated over successive 10 minute windows, with data plotted each minute. For a given 10-minute window, therefore, the first plotted value represents 1 minute of accumulated data, while the last plotted value represents an accumulation of 10 minutes. Percent utilization figures are updated each second. All times are presented in simulated time scale. Tabular displays also are windowed, presenting data accumulated over the previous 10 minutes. Both scenarios are executed with the updated European network model (described in Appendix B) and with up to five reattempts per block call. Link and node designation numbers are presented in Figure 14. This figure also displays the nominal allocation of terrestrial and satellite voice channels within the European theater.

1.4.2.1 Scenario 1: Earth Station Failure

In Scenario 1 the failure of the earth station at Feldberg results in the Feldberg/Conus gateway link being reduced from its 47 satellite and terrestrial trunks to its 8 terrestrial trunks. A comparison of Figures 15 and 16 shows both immediate and priority subscribers seriously affected, but routine service only moderately degraded. This is due to the precedence distribution of the gateway traffic which is very heavily weighted at the immediate and priority levels. All gateway links become extremely saturated as a result of the alternate routing attempts among the gateway links. Figure 17 illustrates the effects resulting from reallocating satellite capacity at the alternate gateway switches of Hillingdon and Mt. Vergine, which receive additional allocations of 20 and 19 voice channels, respectively. As demonstrated in this figure, network grade of service is essentially returned to normal soon after reallocation is implemented. Restoration is possible because of the alternate gateway routing capability.



Sometimes a Spill Node

No. of Satellite Trunks

( ) No. of Land Trunks

1. Conus Gateway to Europe
2. Hillingdon, England
3. Feldberg, Germany
4. Langerkopf, Germany
5. Mt. Vergine, Italy
6. Martlesham Heath, England
7. Schoenfeld, Germany
8. Donnersberg, Germany
9. Humosa, Spain
10. Coltano, Italy
11. Mt. Pateras, Greece

Figure 14. European AUTOVON

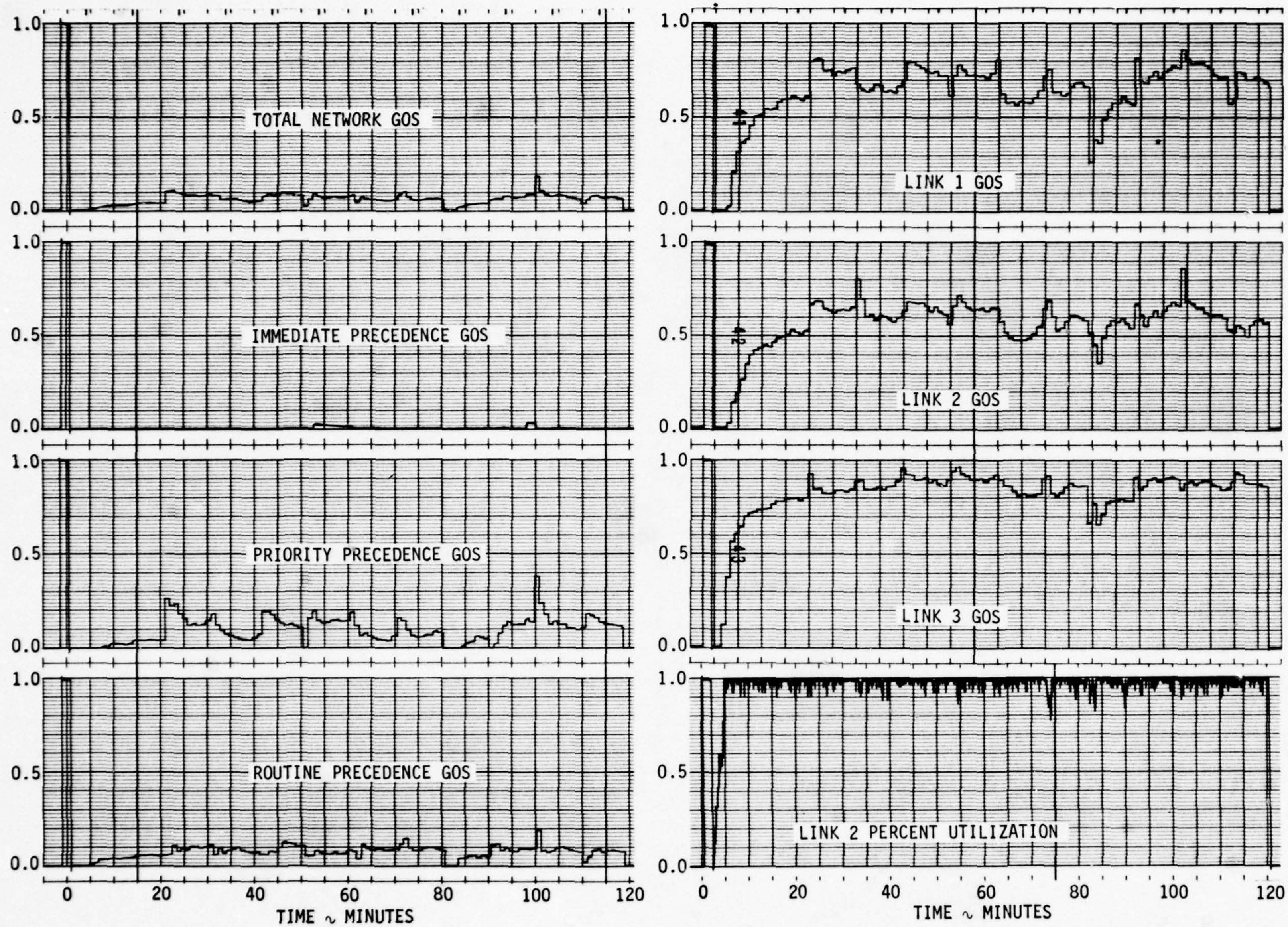


Figure 15. Scenario 1: Normal Busy Hour Response

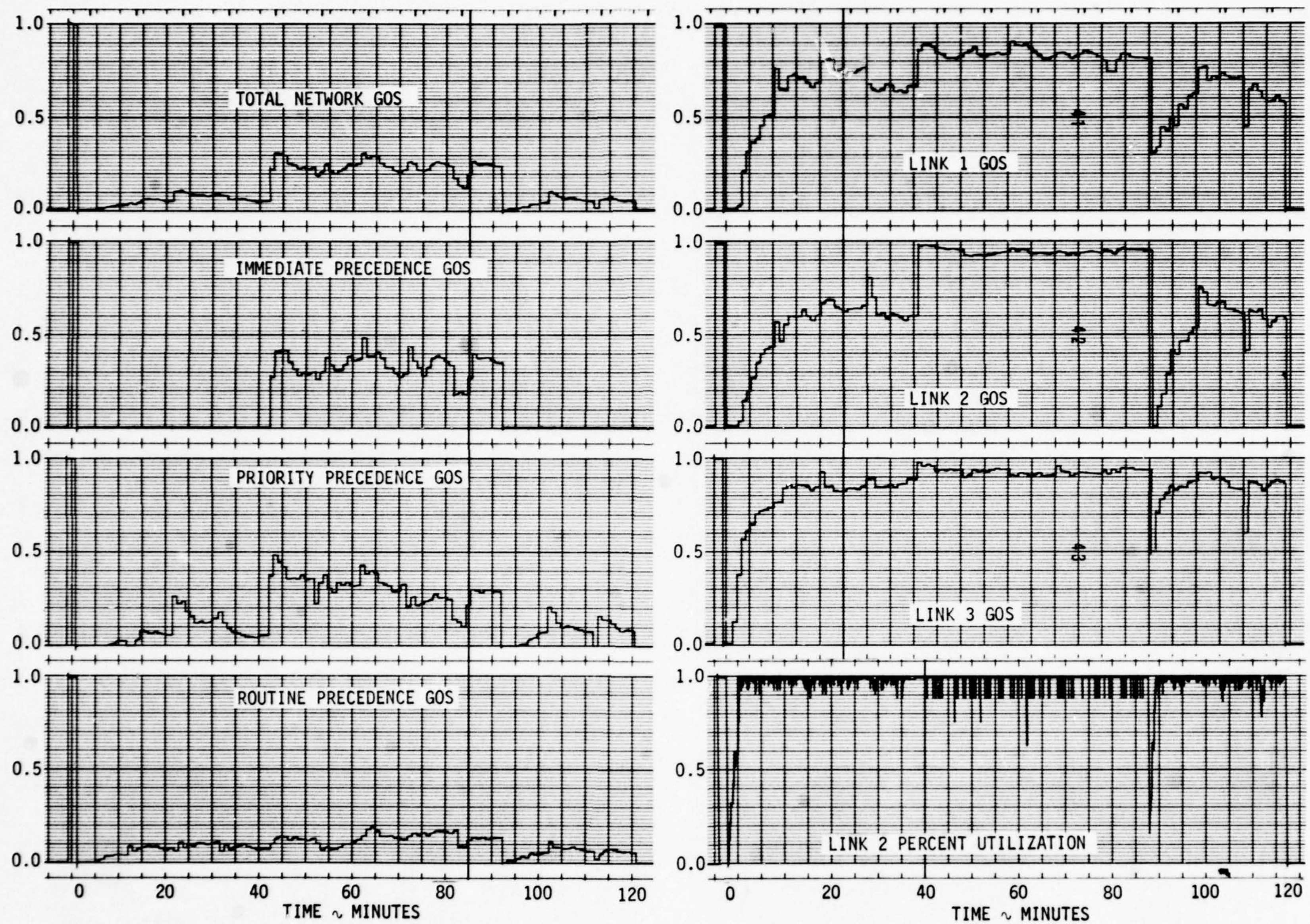


Figure 16. Scenario 1: Perturbation and Restoral Response

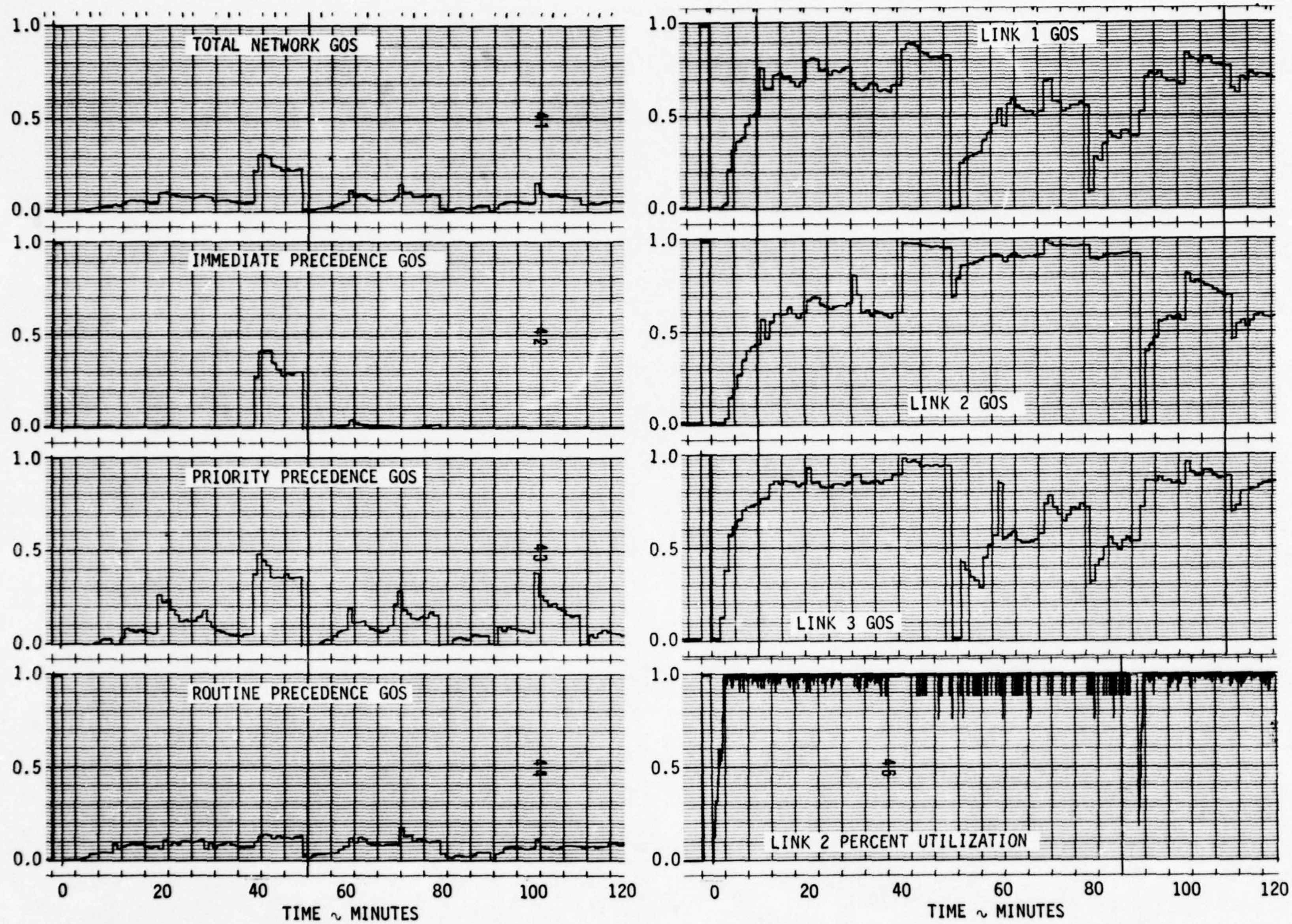


Figure 17. Scenario 1: Response with Satellite Reallocation at 50 Minutes

1.4.2.2 Scenario 2: Multiple Link Loss

Scenario 2 demonstrates the interactive control process involving isolation of problem areas and design of control action to reduce network degradation. The perturbation consists of complete failure at time 40 minutes of the Donnersberg/Feldberg (14) and Langerkopf/Feldberg (10) logical links. The behavior of the theater-level grade of service indices and of significant links is presented in Figures 18 and 19 for normal and perturbed networks, respectively. Although normally the immediate precedence traffic essentially is nonblocking, the failure of links 10 and 14 logically isolates several node pairs to result in a significant immediate call blockage. Lower precedences also experience elevated GOS values. Figures 20 and 21 illustrate several controller position displays that are useful for locating trouble locations, and in helping to formulate effective control directives. Figure 20, a 10-minute windowed display, presents typical normal busy hour statistics, while Figure 21 provides similar statistics viewed 10 minutes after the perturbation. Following are results from distressed network displays as compared to normal behavior:

1 Twelve percent of immediate (2) blockage and elevated blockage occurs at the lower precedences

2 Total blockage of links 10 (Langerkopf/Feldberg) and 14 (Donnersberg/Feldberg) occurs due to link failures

3 Decreased blockage on link 2 (Conus/Feldberg) indicates loss of significant amount of gateway traffic through Feldberg

4 Greatly elevated blockage at source nodes 3 (Feldberg), 4 (Langerkopf), and 8 (Donnersberg) indicates potential losses of logical connectivity in this region.

The controller displays strongly suggest that the majority of the observed immediate traffic blockage is due to lack of any logical paths connecting Feldberg, Donnersberg and Langerkopf. Routing tables (Appendix B) reveal that Feldberg is isolated logically from Donnersberg and Langerkopf with links 10 and 14 out of service. A probable solution is to generate and implement routing tables updates at selected switches to restore sufficient logical connectivity to handle at least the majority of the immediate precedence traffic. This is not a trivial task. To provide the connectivity without causing "ring-around-the-rosy" conditions, tables at Donnersberg (8), Langerkopf (4), and Feldberg (3) were revised, and selected alternate paths were removed from Schoenfeld (7), Humosa (9), and Mt. Pateras (11). The controller interaction sequence with resulting routing table updates is illustrated in Figure 22. Figure 23 demonstrates the effectiveness of this control when implemented at 10 minutes following the link failures. Immediate precedence blockage is reduced from about 15 percent to about 5 percent. Total network blockage is reduced from about 25 percent to about 12 percent.

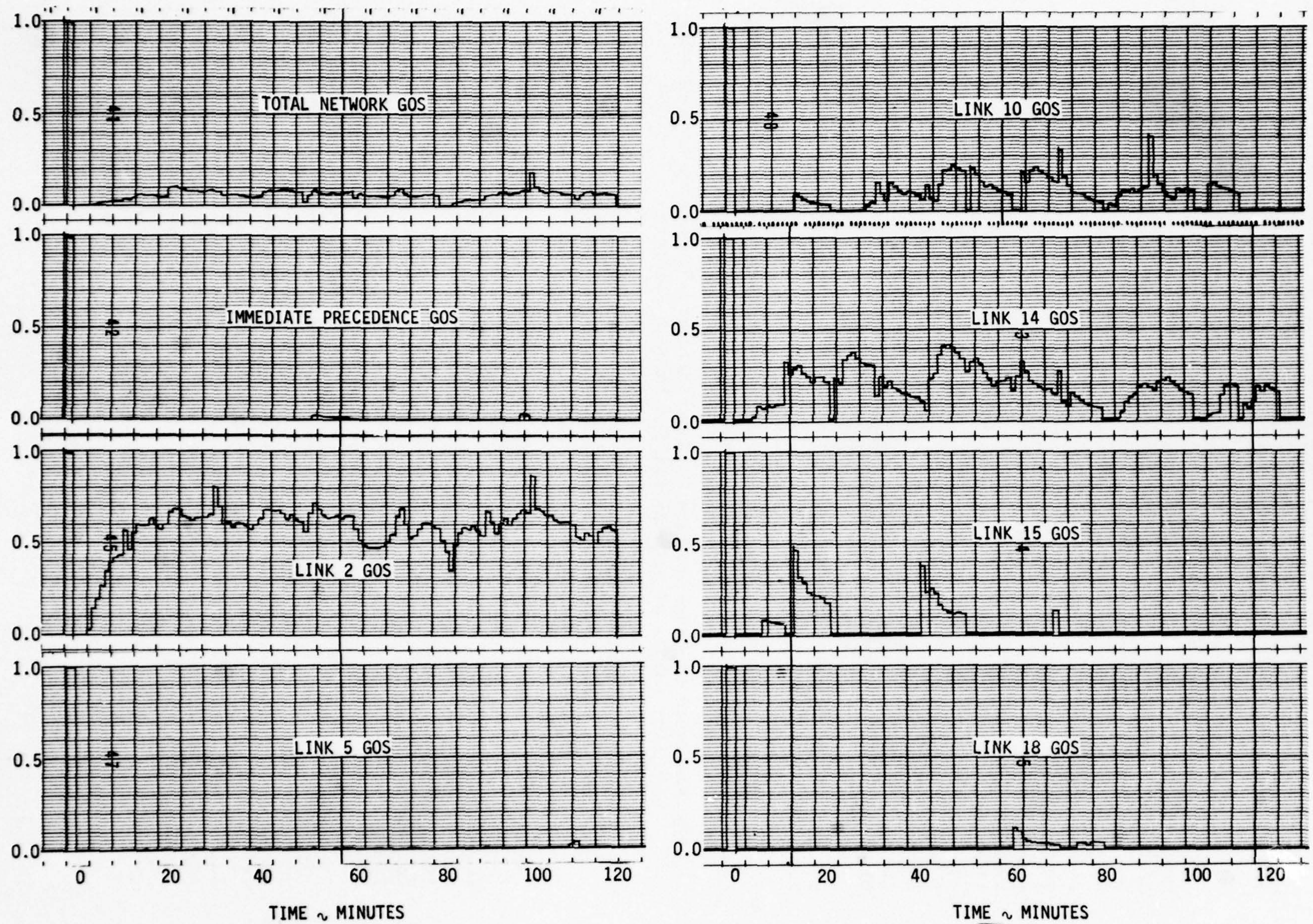


Figure 18. Scenario 2: Normal Busy Hour Response

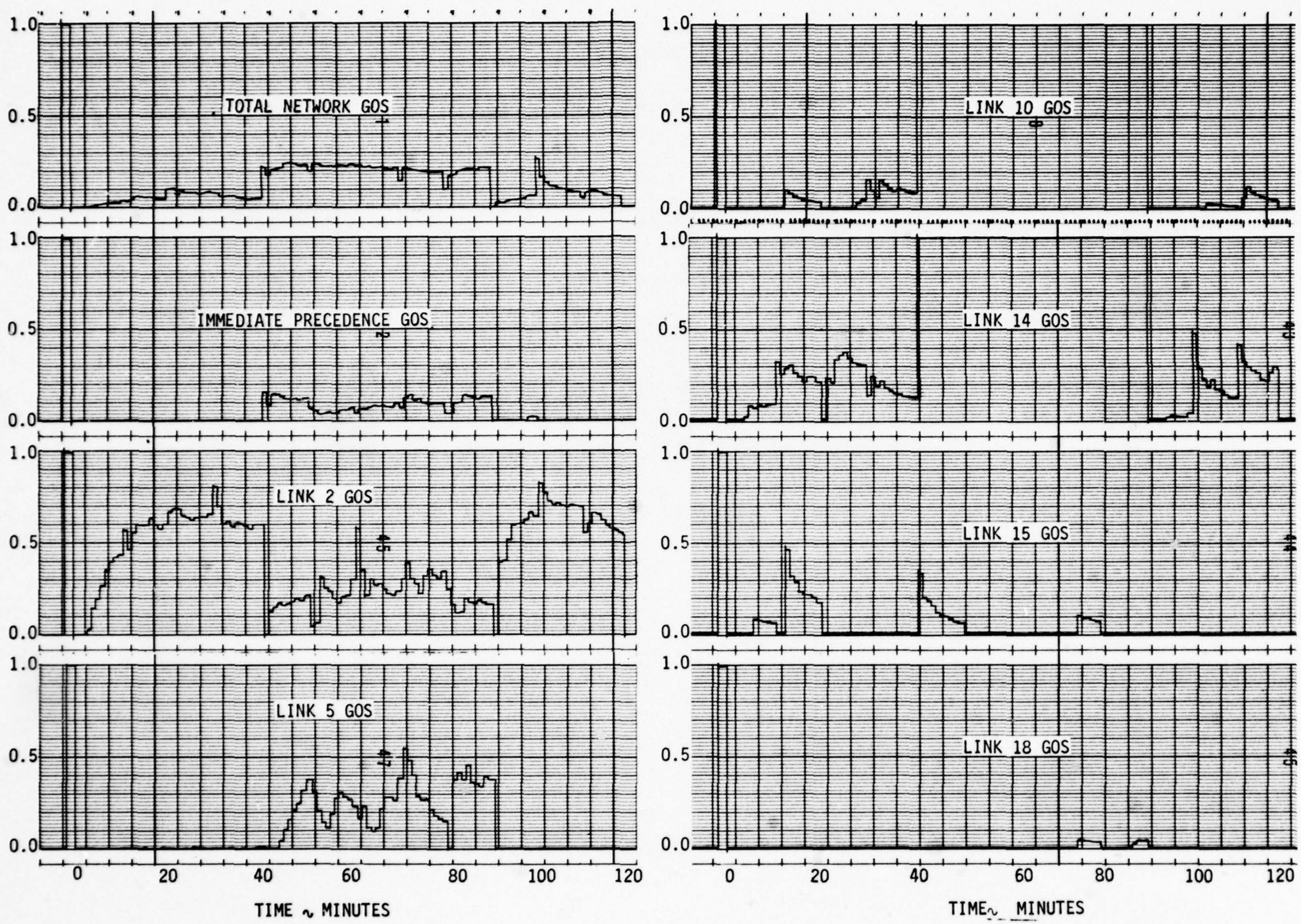


Figure 19. Scenario 2: Perturbation and Restoral Response

***** 0:40: 0*****

ACCUMULATED TOTAL NETWORK STATISTICS

ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM
871	41	830	104	0.0471	0.1253

***** 0:40: 0*****

ACCUMULATED NETWORK PRECEDENCE STATISTICS

PREC	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	PREC
0	0	0	0	0	0.0000	0.0000	0
1	4	0	4	0	0.0000	0.0000	1
2	232	0	232	0	0.0000	0.0000	2
3	221	12	209	49	0.0543	0.2344	3
4	414	29	385	55	0.0700	0.1429	4

***** 0:40: 0*****

*ACCUMULATED LINK/PRIORITY GOS STATUS

LINK A	TOTAL	P0	P1	P2	P3	P4
	BLCK/ATTM=X.XX	BLCK/ATTM	BLCK/ATTM	BLCK/ATTM	BLCK/ATTM	BLCK/ATTM
1**	170/ 300=0.57	0/ 0	1/ 1	85/ 153	54/ 95	30/ 51
2 *	205/ 427=0.48	0/ 0	1/ 4	96/ 212	71/ 147	37/ 64
3***	173/ 208=0.83	0/ 0	1/ 1	89/ 108	51/ 62	32/ 37
4	0/ 59=0.00	0/ 0	0/ 0	0/ 29	0/ 16	0/ 14
5	0/ 51=0.00	0/ 0	0/ 0	0/ 17	0/ 21	0/ 13
6	0/ 50=0.00	0/ 0	0/ 0	0/ 26	0/ 13	0/ 11
7	0/ 60=0.00	0/ 0	0/ 0	0/ 17	0/ 8	0/ 35
8 *	28/ 61=0.46	0/ 0	0/ 1	9/ 19	5/ 17	14/ 24
9	0/ 35=0.00	0/ 0	0/ 0	0/ 12	0/ 9	0/ 14
10	11/ 148=0.07	0/ 0	1/ 3	1/ 49	1/ 42	8/ 54
11	0/ 96=0.00	0/ 0	0/ 0	0/ 39	0/ 34	0/ 23
12	0/ 20=0.00	0/ 0	0/ 0	0/ 6	0/ 2	0/ 12
13	0/ 27=0.00	0/ 0	0/ 0	0/ 1	0/ 6	0/ 20
14	19/ 179=0.11	0/ 0	0/ 3	5/ 58	3/ 46	11/ 72
15	0/ 29=0.00	0/ 0	0/ 0	0/ 6	0/ 7	0/ 16
16	0/ 9=0.00	0/ 0	0/ 0	0/ 1	0/ 3	0/ 5
17	0/ 106=0.00	0/ 0	0/ 1	0/ 5	0/ 16	0/ 84
18	0/ 52=0.00	0/ 0	0/ 1	0/ 15	0/ 15	0/ 21
19	1/ 50=0.02	0/ 0	0/ 0	0/ 10	0/ 16	1/ 24
20	1/ 26=0.04	0/ 0	0/ 0	0/ 8	0/ 5	1/ 13
21	0/ 47=0.00	0/ 0	0/ 0	0/ 9	0/ 18	0/ 20
22	16/ 55=0.29	0/ 0	0/ 0	1/ 5	0/ 5	15/ 45
23	0/ 31=0.00	0/ 0	0/ 0	0/ 1	0/ 6	0/ 24
24	2/ 43=0.05	0/ 0	0/ 0	0/ 2	0/ 10	2/ 31
25	0/ 25=0.00	0/ 0	0/ 0	0/ 3	0/ 4	0/ 18
26	7/ 26=0.27	0/ 0	0/ 0	1/ 2	1/ 5	5/ 19

***** 0:40: 0*****

ACCUMULATED SOURCE NODE NETWORK STATISTICS

NODE	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	NODE
1	129	10	119	31	0.0775	0.2605	1
2	68	5	63	10	0.0735	0.1587	2
3	134	6	128	12	0.0448	0.0938	3
4	140	6	134	16	0.0429	0.1194	4
5	47	0	47	3	0.0000	0.0638	5
6	48	1	47	1	0.0208	0.0213	6
7	39	2	37	3	0.0513	0.0811	7
8	120	6	114	17	0.0500	0.1491	8
9	69	3	66	6	0.0435	0.0909	9
10	38	0	38	1	0.0000	0.0263	10
11	39	2	37	4	0.0513	0.1081	11

Figure 20. Preperturbation Displays

***** 0:50: 0*****
ACCUMULATED TOTAL NETWORK STATISTICS

ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM
921	210	711	109	0.2280	0.1533

***** 0:50: 0*****
ACCUMULATED NETWORK PRECEDENCE STATISTICS

PREC	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	PREC
0	0	0	0	0	0.0000	0.0000	0
1	5	0	5	0	0.0000	0.0000	1
2	265	32	233	2	0.1208	0.0086	2
3	216	44	172	34	0.2037	0.1977	3
4	435	134	301	73	0.3080	0.2425	4

***** 0:50: 0*****
*ACCUMULATED LINK/PRIORITY GOS STATUS

LINK A	TOTAL	P0	P1	P2	P3	P4
	BLCK/ATTM=X.XX	BLCK/ATTM	BLCK/ATTM	BLCK/ATTM	BLCK/ATTM	BLCK/ATTM
1**	213/ 326=0.65	0/ 0	3/ 4	113/ 186	62/ 84	35/ 52
2	41/ 314=0.13	0/ 0	1/ 3	21/ 166	13/ 94	6/ 51
3***	205/ 259=0.79	0/ 0	4/ 5	118/ 152	54/ 65	29/ 37
4	0/ 56=0.00	0/ 0	0/ 2	0/ 21	0/ 18	0/ 15
5	34/ 127=0.27	0/ 0	0/ 0	17/ 65	10/ 37	7/ 25
6	0/ 29=0.00	0/ 0	0/ 1	0/ 16	0/ 5	0/ 7
7	0/ 58=0.00	0/ 0	0/ 1	0/ 14	0/ 15	0/ 28
8**	52/ 102=0.51	0/ 0	1/ 4	23/ 54	15/ 25	13/ 19
9	7/ 42=0.17	0/ 0	1/ 1	3/ 15	2/ 9	1/ 17
10***	322/ 322=1.00	0/ 0	0/ 0	119/ 119	90/ 90	113/ 113
11	24/ 112=0.21	0/ 0	1/ 3	13/ 52	2/ 24	8/ 33
12	0/ 34=0.00	0/ 0	0/ 0	0/ 10	0/ 6	0/ 18
13	0/ 37=0.00	0/ 0	0/ 0	0/ 11	0/ 10	0/ 16
14***	344/ 344=1.00	0/ 0	3/ 3	119/ 119	85/ 85	137/ 137
15	2/ 35=0.06	0/ 0	0/ 0	0/ 5	0/ 5	2/ 25
16	4/ 19=0.21	0/ 0	0/ 0	0/ 1	0/ 5	4/ 13
17	0/ 161=0.00	0/ 0	0/ 0	0/ 19	0/ 35	0/ 107
18	0/ 101=0.00	0/ 0	0/ 1	0/ 52	0/ 19	0/ 29
19	0/ 55=0.00	0/ 0	0/ 1	0/ 16	0/ 10	0/ 28
20	5/ 19=0.26	0/ 0	0/ 0	1/ 4	2/ 5	2/ 10
21	0/ 53=0.00	0/ 0	0/ 1	0/ 14	0/ 12	0/ 26
22 *	23/ 67=0.34	0/ 0	1/ 1	0/ 2	8/ 22	14/ 42
23	9/ 40=0.23	0/ 0	0/ 0	1/ 6	0/ 7	8/ 27
24	2/ 30=0.07	0/ 0	0/ 0	1/ 2	0/ 8	1/ 20
25	4/ 47=0.09	0/ 0	0/ 0	1/ 5	1/ 8	2/ 34
26	2/ 33=0.06	0/ 0	0/ 0	0/ 3	0/ 8	2/ 22

***** 0:50: 0*****
ACCUMULATED SOURCE NODE NETWORK STATISTICS

NODE	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	NODE
1	157	20	137	34	0.1274	0.2482	1
2	59	6	53	12	0.1017	0.2264	2
3	130	65	65	7	0.5000	0.1077	3
4	134	55	79	16	0.4104	0.2025	4
5	48	0	48	5	0.0000	0.1042	5
6	65	6	59	13	0.0923	0.2203	6
7	43	2	41	1	0.0465	0.0244	7
8	122	51	71	6	0.4180	0.0845	8
9	57	1	56	7	0.0175	0.1250	9
10	53	2	51	1	0.0377	0.0196	10
11	53	2	51	7	0.0377	0.1373	11

Figure 21. Postperturbation Displays

```
*CONTROL IMPLEMENTATION*
ENTER NEGATIVE NUMBER TO QUEUE AND POSITIVE NUMBER TO IMPLEMENT THIS AND
OTHERQUEUED CONTROLS
TO RESET ALL CONTROLS                        RES  TYPE  1 OR  -1
FOR DESTINATION CODE CANCELLATION            DCC  TYPE  2 OR  -2
FOR LINE LOAD CONTROL                        LLC  TYPE  3 OR  -3
FOR LINK DIRECTIONALIZATION                  LDR  TYPE  4 OR  -4
FOR LINK ACCESS BY PRECEDENCE                LAP  TYPE  5 OR  -5
FOR PRIMARY ONLY OR LIMITED ROUTING          PRO  TYPE  6 OR  -6
TO ALTER ROUTING TABLE                       ART  TYPE  7 OR  -7
TO RESTORE NOMINAL ROUTING TABLE             RRT  TYPE  8 OR  -8
TO IMPLEMENT QUEUED CONTROLS                      TYPE       -99
TO DELETE QUEUE                                   TYPE 99
TO TERMINATE CONTROL INPUT                        TYPE A BLANK
ENTER CONTROL TYPE
*INPUT DATA*7
*ALTER ROUTING TABLE FROM NODE *NS* TO NODE *ND* WHERE *NI* AND *SI*,
WHERE I=1,MPPN,ARE RESPECTIVELY TANDEM NODE AND SPILL
INDICATOR FOR THE I-TH PATH CONNECTING *NS* AND *ND*
IF(NI.LT.0) THEN I-TH PATH WILL BE LEFT UNCHANGED.
ENTER BLANK LINE TO TERMINATE ROUTINE.
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*3 4 5 1 10 1
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*3 8 7 1 5 1
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*4 3 7 1 2 1
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*5 3 3 1
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*5 4 8 1
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*5 8 8 1 10 1
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*7 4 4 1 8 1
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*7 8 8 1 4 1
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*8 3 5 1 10 1
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*9 3 5 1 2 1
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*9 4 8 1 2 1 5 1
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*11 3 5 1
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...
*INPUT DATA*
                          ***** 0:50: 0*****
*ROUTING TABLE FOR NODES *NS* TO *ND* WITH TANDEM PATH NODES *NTI**
               *AND SPILL INDICATORS *SI* FOR PATHS *I**
 NS ND  NT1:S  NT2:S  NT3:S  NT4:S
  3  4    5:1   10:1
  3  8    7:1    5:1
  4  3    7:1    2:1
  5  3    3:1
  5  4    8:1
  5  8    8:1   10:1
  7  4    4:1    8:1
  7  8    8:1    4:1
  8  3    5:1   10:1
  9  3    5:1    2:1
  9  4    8:1    2:1    5:1
 11  3    5:1
ENTER CONTROL TYPE
```

Figure 22. Interactive Control Sequence

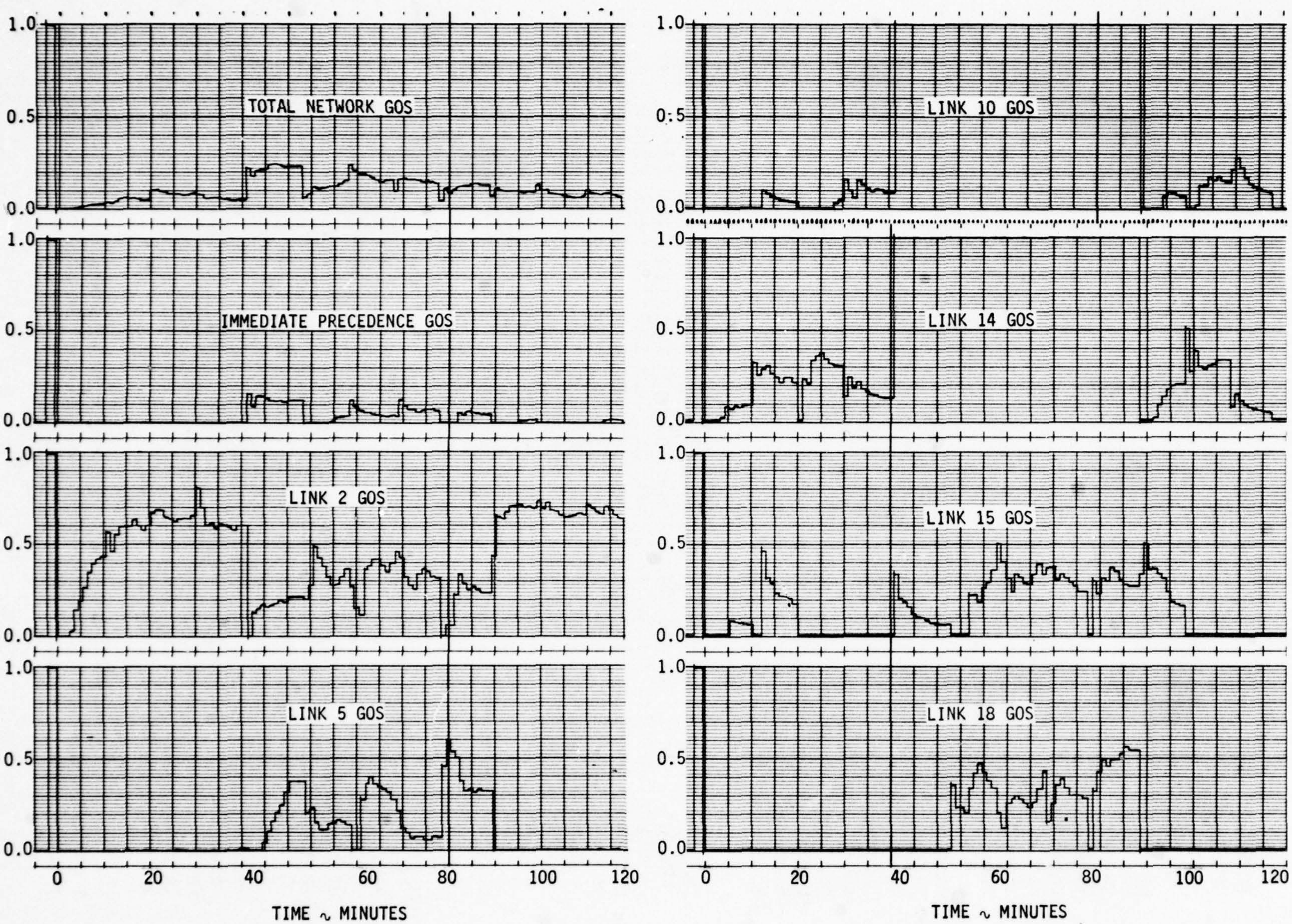


Figure 23. Scenario 2: Response with Revised Routing at 50 Minutes

While routing table updates significantly improve stressed network performance, some potential benefits are lost because of pending "ring-around-the-rosy" problems. Also, the controller's job is burdened by this consideration, and the time required to verify the routes results in longer delays in control implementation. Channel reassignment (either manually or automatically implemented) promises to provide an alternate means of restoring logical connectivity quickly while minimizing risks. Providing centralized channel reassignment capability exists, the controller may view current displays such as provided in Figure 21 to ascertain which links have available capacity. Here, links 4, 6, 7, 12, 13, 17, 18, 19, and 21 have pegged no blocked calls in the previous 10-minute interval. Also, links 5 and 11, normally with very low blockage, now indicate heavy blockage due to alternate routing around the destructed links. The network diagram, Figure 14, may be inspected to determine potential reassignments. Five trunks from each of links 4 and 5 are reassigned to provide five trunks logically replacing link 10. Similarly, five trunks from each of links 11 and 18 and three trunks from 15 and 25 are reassigned to link 14. Since the path from Donnersberg to Schoenfeld (link 23) actually is transmitted through Feldberg, ten trunks from link 23 are reassigned to provide an additional ten trunks for links 14 and 13. The total reassignment is summarized in Figure 24. Figure 25 demonstrates the significant restoration of immediate service achieved with this simple reassignment plan. Reassignment was implemented 10 minutes following the perturbation.

```
                                *****  0:50: 0*****
* LINK CAPACITY CHANGE:   LINK=  4   OLD CAP= 15   NEW CAP = 10*
* LINK CAPACITY CHANGE:   LINK=  5   OLD CAP= 14   NEW CAP =  9*
* LINK CAPACITY CHANGE:   LINK= 11   OLD CAP= 20   NEW CAP = 15*
* LINK CAPACITY CHANGE:   LINK= 18   OLD CAP= 15   NEW CAP = 10*
* LINK CAPACITY CHANGE:   LINK= 23   OLD CAP= 12   NEW CAP =  8*
* LINK CAPACITY CHANGE:   LINK= 13   OLD CAP= 13   NEW CAP = 19*
* LINK CAPACITY CHANGE:   LINK= 15   OLD CAP= 11   NEW CAP =  8*
* LINK CAPACITY CHANGE:   LINK= 25   OLD CAP= 12   NEW CAP =  9*
* LINK CAPACITY CHANGE:   LINK= 10   OLD CAP=  0   NEW CAP =  5*
* LINK CAPACITY CHANGE:   LINK= 14   OLD CAP=  0   NEW CAP = 14*
```

Figure 24. Channel Reassignment Strategy

1.5 Interactive Network Simulator Enhancements

Since Contract DCA100-75-C-0058, numerous enhancements to the network simulator have been implemented, including an improved data base and increased display, control, scenario, and routing capability. A conversational interactive program has been implemented to assist the simulation user and provide an instrument for controller studies. Network definition and initialization options have been expanded, and significant improvements in stripplot and time-scaling options achieved. Some enhancements are natural results of program conversion from the EAI 8900 computing system to the Interdata 8/32 computing system, and others result from the increased storage and speed of the Interdata system.

The conversational program represents a major simulator modification. A comprehensive set of options permit use of the simulator with a minimum of instruction. Options are self-explanatory and direct the controller/

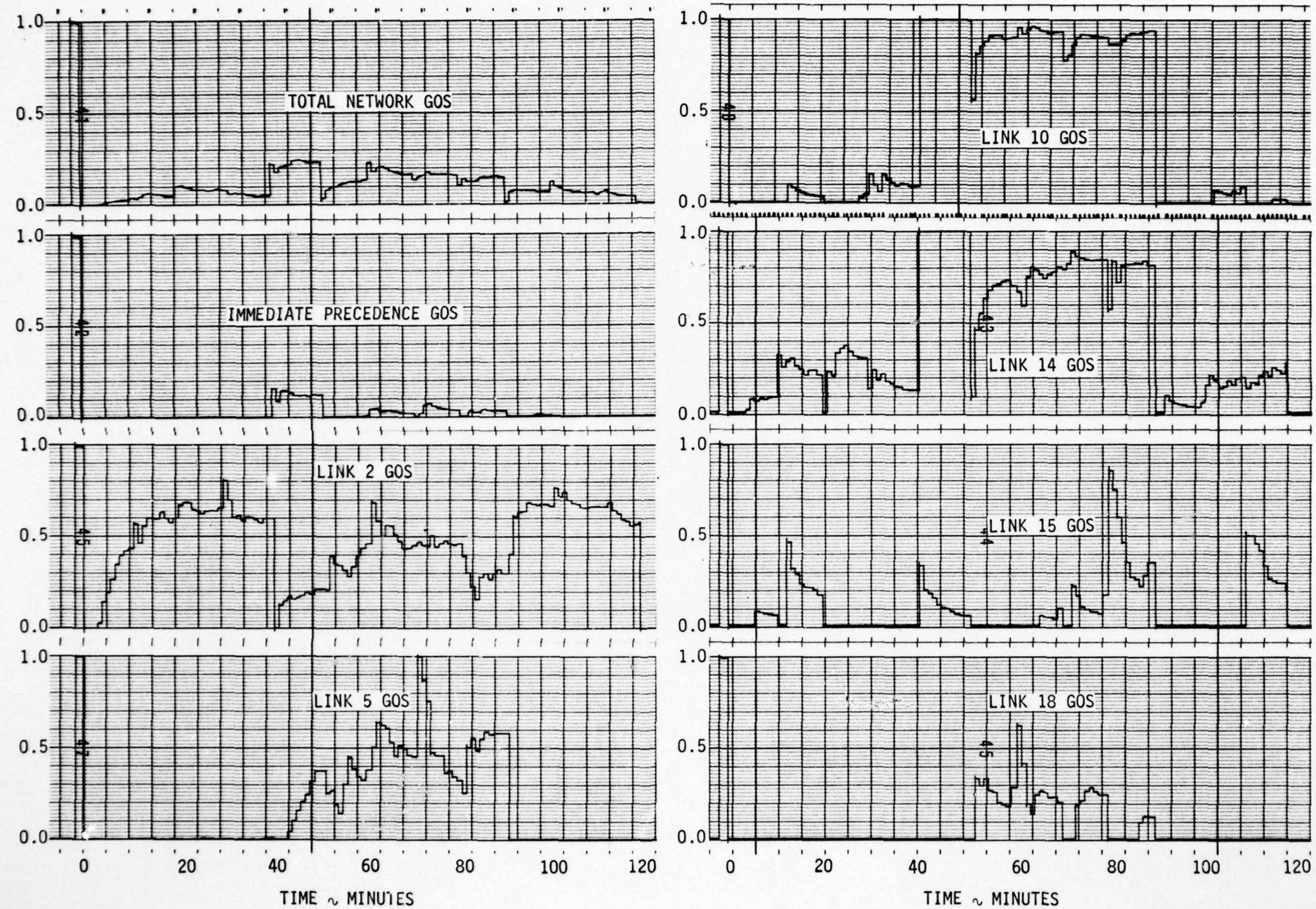


Figure 25. Scenario 2: Response with Channel Reassignment at 50 Minutes

operator through desired network definition and interaction. Batch-mode capability is preserved to maintain the usefulness of the simulator as a noninteractive analytical tool.

The dynamic interactability of the network simulator is enhanced by using the multitask capabilities of the Interdata 8/32 computer. The controller now may view stop-action displays interactively while the network simulation is executing simultaneously in faster than real time. In addition to increased interactive display, control, and scenario options, the interactive operator now has improved time-scaling and stripplotting flexibility. The operator can alter the simulator time scale dynamically to permit time scales from real time to limits imposed by the simulated network. For the current overseas AUTOVON simulation, this limit is about 60 times faster than real time. The operator also can assign, dynamically, stripplot options such that any of 10 basic stripplot displays can be assigned to any of the 8 or 16 available stripplot channels (8 channels for remote operation). These assignments can be altered by the local or remote operator, either prior to or during a simulation run.

The data base module is enhanced to provide improved display capability and increase simulator speed during call preemption situations. In particular, link occupancy is now tabulated by precedence and direction. Link and node traffic statistics are tabulated by precedence and maintained for both accumulative and windowed values. As in the previous simulator, both subscriber and network statistics are maintained.

Several modifications were made to the scenario module. The option to queue perturbations for simultaneous implementation of complex scenarios is added. The traffic load model has increased flexibility. The updated overload model allows changes from single source to single destination at single priority to general change of all traffic. Programmed options allow independent selection of one or a group of source nodes, one or a group of destination nodes, and one or a group of priorities to be effected. Programmed default options facilitate selection of "all nodes" or "all priorities."

Several significant enhancements were implemented in the Controller Option module. Dynamic control options can be entered for immediate implementation or queued so that several controls become effective simultaneously. The Destination Code Cancellation (DCC) control model is expanded to allow independent implementation on a node-to-node basis. Hence, several different source nodes can invoke DCC to a given destination at different priority levels. Link Access Restriction by Precedence is added to the possible control options. Here, access to given links may be restricted (bidirectionally) to calls above a certain priority level. The Primary Only Routing option is expanded to allow implementation at single nodes or for groups of nodes. Also, the allowable number of alternates to be active at each node can now be altered to independently restrict each node between the limits of primary routing only and unlimited access of defined alternates. This permits routing restrictions without the necessity of redefining the routing table.

The tabular display module is revamped. In particular, new displays are formatted, and previous displays reformatted to separate subscriber and

network statistics. The subscriber statistics include calls denied access by the network and which are not tabulated in the network data base. Link and node occupancy displays are augmented with capacity indication. Link and node occupancy tables by direction and precedence are added to present the new occupancy-precedence data base. The following displays are reformatted to separate the subscriber and network statistics: Total Statistics, Statistics by Precedence, Statistics by Source Node, Statistics by Source Node and Precedence, Source Node to Destination Node Statistics, Switch-Precedence GOS Statistics, Link-Precedence GOS Statistics, Switch-Precedence Preemption Statistics, and Link-Precedence Preemption Statistics. Each display can be called all, or in part, either by the interactive controller or by batch mode operation. Routing table displays also are added to controller accessible options.

The routing module is enhanced to increase flexibility of routing action, reduce computation time, and prevent inadvertant operator selection of untenable routes. Several minor alterations with respect to crankback and preemption policies with the spill-forward routing plan are implemented. While extensive use of these alternates is not foreseen, limited use can be invoked to investigate potential consequences. The preemption algorithm is modified to utilize the expanded link and node occupancy data base (by precedence). This results in a significant reduction of CPU time required for preemptive searches. Each route attempted is now checked for conditions of "ring-around" and "too many tandems." This warns the operator/controller of untenable routes created by the operator or by independent switch operation.

Several enhancements facilitate network definition and initialization. A network can now be defined or altered via remote terminal entry, or via card, magnetic tape, or disc file input. The refined data input/output option is modified in the current simulator to restore/save the operating environment completely - network definition, scenario and control status, operational data base, and simulation time. This permits rapid reinitialization of the simulator to a presaved status, either quiescent or active. In the active situation, for example, the operator can save and subsequently reinitialize the simulator following a scenario sequence but prior to a control sequence. Hence, the operator can readily evaluate the effect of different control sequences to the same scenario without having to resequence the scenario to the time of departure. Reinitialization is accomplished in a single read operation of a 300 (approximate) sector contiguous disc file and, with operator interaction, can be accomplished in 5 to 10 seconds.

In general, the enhancements represented in the current simulator provide improved computational speed, flexibility, interactibility, and ease of operation. The capability of the simulator to accurately model AUTOVON events and control actions is also improved.

Table 2 summarizes the significant attributes of the current network simulation program. The following sections discuss the current status of several altered program functions and modules in greater detail. In particular, the controller task/simulation task interaction and conversational option, and traffic-oriented data base, display, control, and perturbation

TABLE 2. INTERACTIVE NETWORK SIMULATOR CHARACTERISTICS

I. BASIC SIMULATOR

CALL BY CALL
- Poisson distributed off/on times
- Blocked call replacement
- Preempted call replacement

FIVE LEVELS OF PRECEDENCE
- Flash override (preempting)
- Flash (preempting)
- Immediate (preempting)
- Priority (preempting)
- Routine (nonpreempting)

NETWORK DEFINITION DATA
- Connectivity
- Capacities (links and nodes)
  - Blocking or nonblocking switches
  - Link restrictions
- Nominal routing tables
- Nominal traffic levels

ROUTING METHODS
- Originating office control with
  - Spill forward
  - Alternate paths from tandem nodes
- Primary route only

PERTURBATION MODEL
- Node damage and failure
  - Partial
  - Complete
  - Multiple
- Transmission path damage and failure
  - Partial
  - Complete
  - Multiple
- Traffic overload
  - Local
  - Focused
  - General

CONTROL MODEL
- Trunk restriction by precedence
- Traffic load control by precedence
- Primary and alternate routing table update
- Supplemental routing
- Link and node capacity changes
  - Reallocation of satellite trunks
- Directionalization of trunks
- Lockout (destination code cancellation)
- Link access restriction by precedence

DATA REDUCTION TAPE OPTIONS
- Off-line analysis
- Establish correlation of perturbations/observations
- Determine control algorithms for observed perturbations

INTERACTIVE OPERATION
- Menu selection
- Controller/operator dynamic interaction
  - Scenario selection
  - Display selection
  - Fault isolation
  - Control implementation

DYNAMIC TIME SCALE SELECTION
- Controller interaction in real time
- Evaluation of interaction in faster than real time

BATCH MODE OPERATION
- Monte Carlo simulations
- Evaluation of network behavior to perturbation/control sequences
- Sizing studies

REMOTE HYBRID TERMINAL OPERATION

II. RUN TIME DISPLAYS

PREPROGRAMMED IN TIME OR CONTROLLER REQUESTED
- Network plot - with destruct indications
- Link and node occupancy by precedence
- Network GOS and preemption
  - Total network — Total priority
  - Total network — Five priorities
  - Network nodes — Total priority
  - Network nodes — Five priorities
- Link GOS - with threshold alarm status
- Node GOS - with threshold alarm status
- Separate subscriber and network statistics

STRIP CHART DISPLAYS
- Links and nodes
  - Percent utilization
  - GOS (windowed or accumulated)
- Network GOS
  - Total
  - By priority

DYNAMIC STRIPPLOT CHANNEL ALLOCATION

III. SIMULATION STUDIES

SENSITIVITY ANALYSIS TO OPTIMIZE
- Sizing
- Allocation of resources

SCENARIO ANALYSIS TO EVALUATE
- Vulnerability
- Need for redundancy

CONTROL ANALYSIS TO PROVIDE
- Evaluation of current controls
- Evaluation of candidate controls
- Evaluation of control requirements

CONTROLLER TRAINING

CONTROLLER DISPLAY/INTERFACE DESIGN AND EVALUATION

modules are considered. These represent the principle program capabilities from the user's viewpoint.

1.5.1 Interactive Program Structure

The program conversion from the EAI 8900 to the Interdata 8/32 computing system uses the multitasking capabilities of the Interdata 8/32 to establish coordination of the controller/operator actions with the simulation network traffic and routing functions. A two-task program is currently implemented with control, display, and scenario generation all delegated to the Controller (CON) task, while the Simulator (SIM) task is dedicated to generation and routing of network traffic under control and scenario restrictions imposed by CON. Although only two tasks are currently implemented, the intertask structure is readily adapted to permit additional controller or scenario tasks to operate simultaneously. Thus, controller and scenario operations may be separated or multiple controller positions may be established. The remainder of this discussion will be limited to two-task implementation.

The controller task is flowcharted in Figure 26, and is the first task loaded in the normal job setup procedure. A command substitution system (CSS) file is resident on the system disc to facilitate task loading and execution. The system operator types SAUERDCA to load and execute the default CON and SIM task files, or SAUERDCA FILEC, FILES, for example, to load special CON (FILEC) and SIM (FILES) task files. The SAUERDCA.CSS file sets the task partitions, then loads and starts the controller task (CON). The controller task then opens and assigns its input/output files according to a prestored assignment file, and loads the simulator task (SIM) into its designation partition. CON establishes the intertask priority structure which places the I/O bound CON task at a higher priority than the CPU bound SIM task. CON then makes both tasks resident (so they may be cancelled and restarted without having to reload) and starts the SIM task, suspending itself pending SIM task initialization. Following SIM task initialization, CON accepts controller/operator requests and, through interrupt control, permits operator establishment of network parameters, implementation of control and scenario options, data base access and display, and network simulation control, i.e., start, stop, time scale change. Also, upon operator request CON makes itself and SIM nonresident, cancels both tasks, and frees the processor for subsequent jobs.

The SIM task includes the primary task (SIM) and the interrupt processing subtask, QUEUEP. The SIM task flow diagram is presented in Figure 27. When SIM is started, it opens and assigns its I/O units according to a prestored assignment file, and then returns program control to CON pending directive from CON to commence generation and processing of network traffic. Traffic processing continues between processing of CON I/O requests for a predetermined time span or until cancellation or suspension by CON. On normal termination or cancellation, SIM returns to wait status pending subsequent run requests. The interrupt processing subtask of SIM, QUEUEP, is flowcharted in Figure 28. Fundamentally, QUEUEP calls subroutines which manipulate or copy the network parameters or data base according to the CON request. Task

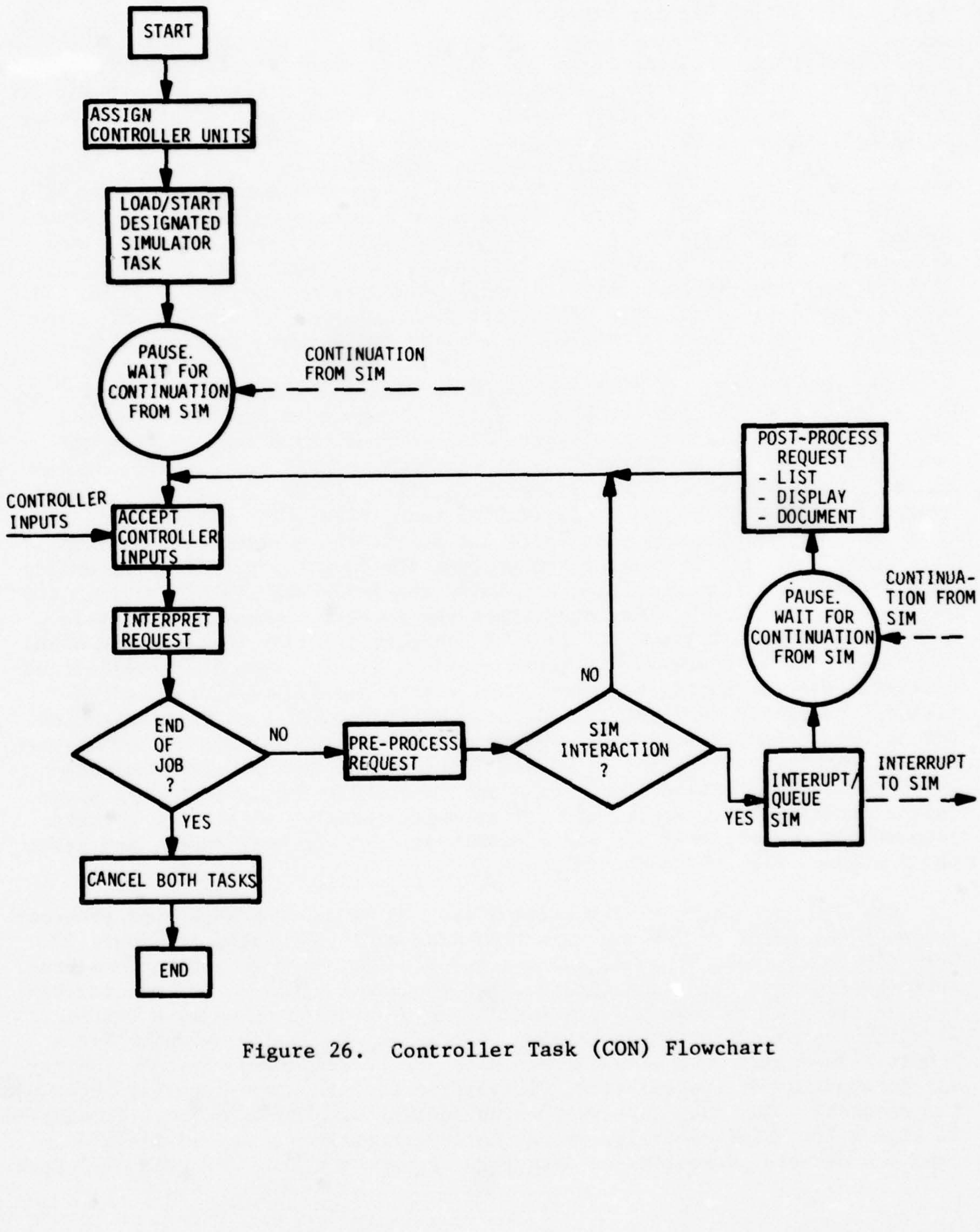


Figure 26. Controller Task (CON) Flowchart

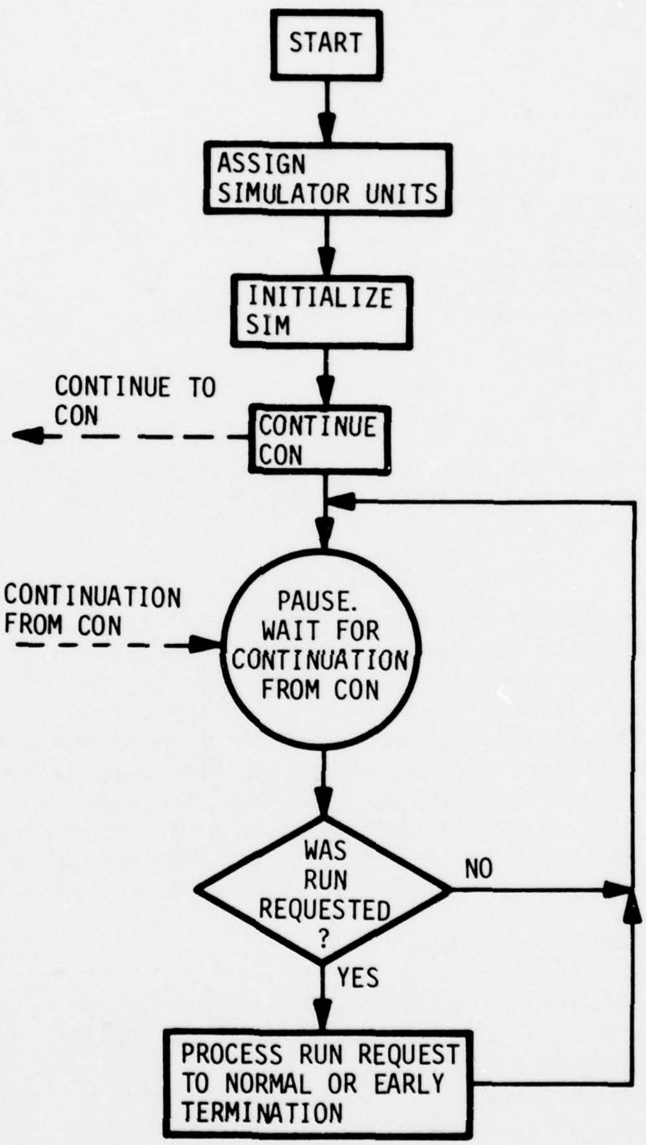


Figure 27. Simulator Task (SIM) Flowchart

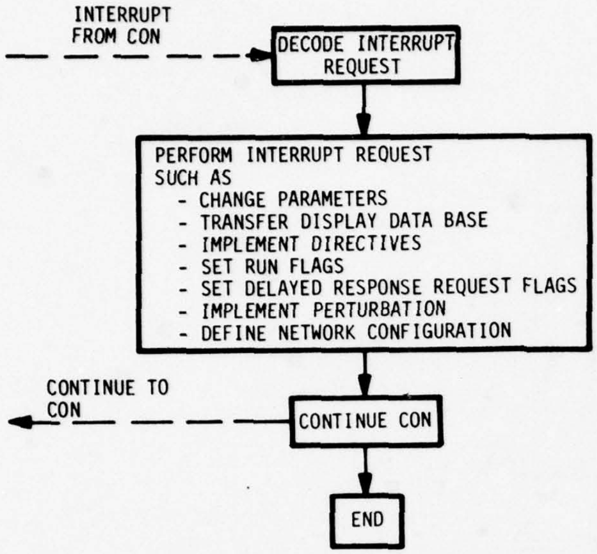


Figure 28. Simulator Interrupt Flowchart

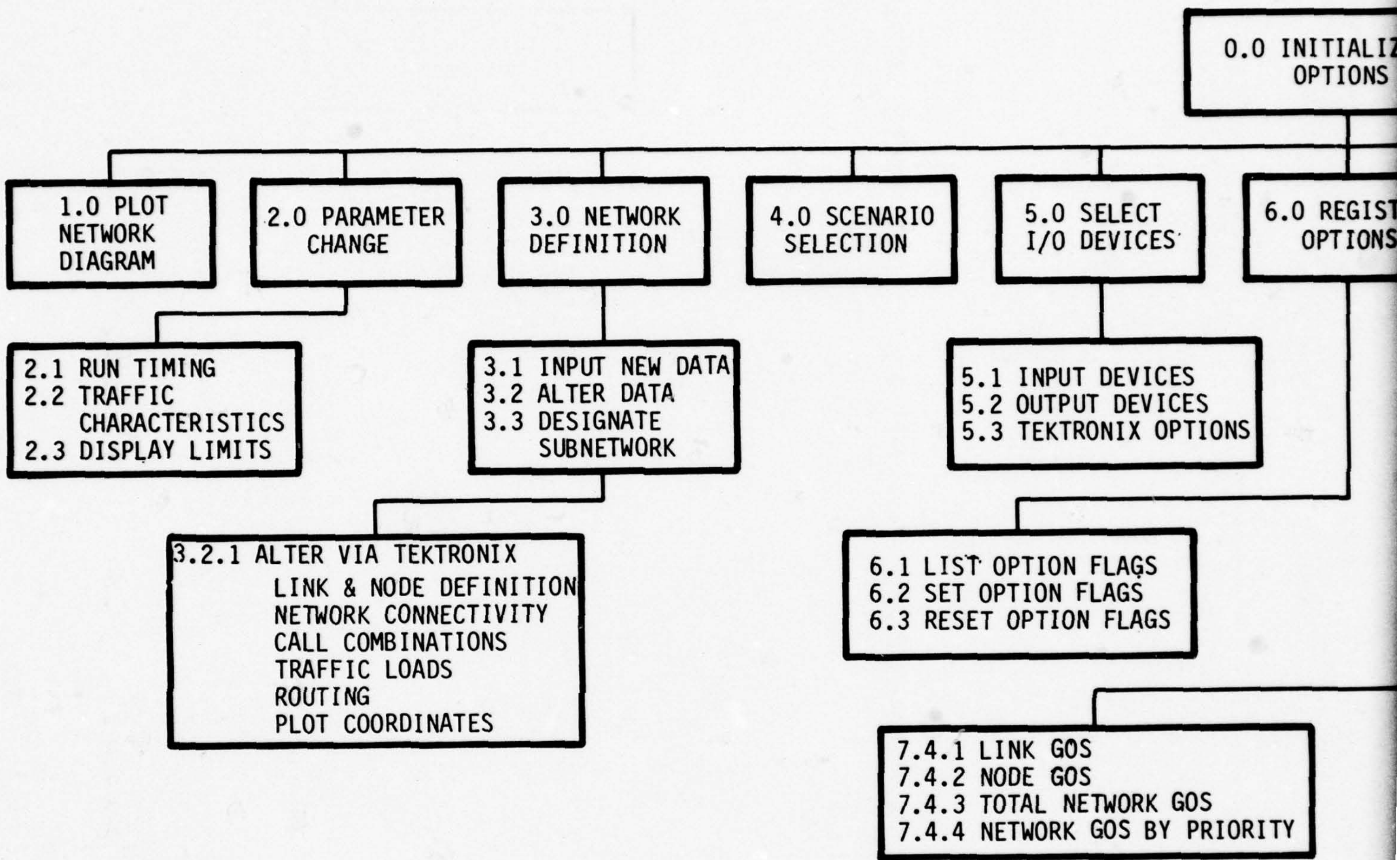
common is used to transfer requests and data base elements between the SIM and CON tasks. Upon completion of the interrupt routine, QUEUEP flags CON to proceed.

A conversational option has been implemented to enhance the interactive operation of the network simulator. With the conversational option, the program operator is presented with a hierarchical series of menu options through which he can define the network to be simulated, specify network and simulator parameters, initiate, terminate, or suspend simulation runs, control the simulation time scale and transient data output, control or perturb the network, and generate controller position displays. The hierarchy of the conversational structure is depicted in Figure 29. A sample menu is presented in Figure 30. Appendix A presents the full set of menu printouts. A blank line input at any level returns control to the next higher level.

1.5.2 Traffic Oriented Data Base

The traffic oriented data base, summarized in Figure 31, provides the basis for call routing and for controller position display options. The traffic data base consists of occupancy, call by call, and route access data base segments, each of which is further subdivided.

The occupancy segment which is the basis for call routing, maintains a continuous count of network resources being used. The occupancy data base is depicted in Figure 32. The numbers in parantheses in this and subsequent figures indicate the implicit dimensions allocated for the specified data base element. These dimensions are in 16-bit half-words unless otherwise specified.


0.0 INITIALIZ
OPTIONS
1.0 PLOT NETWORK DIAGRAM
2.0 PARAMETER CHANGE
3.0 NETWORK DEFINITION
4.0 SCENARIO SELECTION
5.0 SELECT I/O DEVICES
6.0 REGIST
OPTIONS
2.1 RUN TIMING
2.2 TRAFFIC CHARACTERISTICS
2.3 DISPLAY LIMITS
3.1 INPUT NEW DATA
3.2 ALTER DATA
3.3 DESIGNATE SUBNETWORK
5.1 INPUT DEVICES
5.2 OUTPUT DEVICES
5.3 TEKTRONIX OPTIONS
3.2.1 ALTER VIA TEKTRONIX
LINK & NODE DEFINITION
NETWORK CONNECTIVITY
CALL COMBINATIONS
TRAFFIC LOADS
ROUTING
PLOT COORDINATES
6.1 LIST OPTION FLAGS
6.2 SET OPTION FLAGS
6.3 RESET OPTION FLAGS
7.4.1 LINK GOS
7.4.2 NODE GOS
7.4.3 TOTAL NETWORK GOS
7.4.4 NETWORK GOS BY PRIORITY

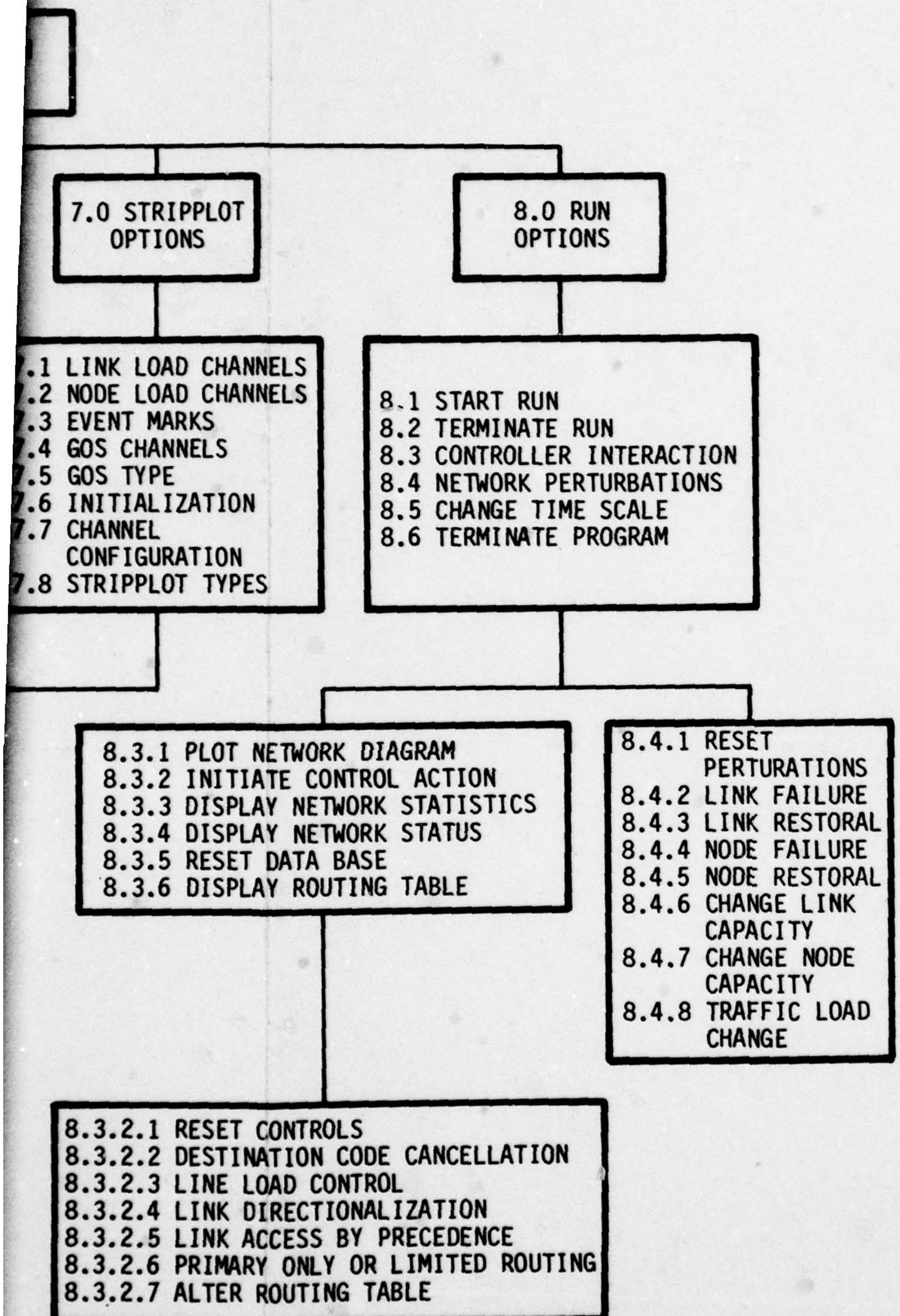


Figure 29. Network Simulator Interaction Option Hierarchy

2

```
                    *** RUN OPTIONS ***

TO START NORMAL RUN                                               TYPE  1
TO TERMINATE RUN AND REEXECUTE                                    TYPE  2
TO INITIATE CONTROLLER INTERACTION                                TYPE  3
TO INITIATE NETWORK PERTURBATION                                  TYPE  4
TO CHANGE PROGRAM TIME SCALE                                      TYPE  5
TO PARTIALLY INITIALIZE NETWORK AND ENVIRONMENT AND THEN RUN      TYPE  6
TO ABORT PROGRAM EXECUTION                                        TYPE  9
4
* INITIATE PERTURBATION *
 ENTER NEGATIVE NUMBER TO QUEUE AND POSITIVE NUMBER TO IMPLEMENT THIS AND
 OTHER QUEUED PERTURBATIONS
 TO RESET ALL PERTURBATIONS                    TYPE  1 OR  -1
 TO REMOVE LINKS                               TYPE  2 OR  -2
 TO RESTORE LINKS                              TYPE  3 OR  -3
 TO REMOVE NODES                               TYPE  4 OR  -4
 TO RESTORE NODES                              TYPE  5 OR  -5
 TO CHANGE LINK CAPACITIES                     TYPE  6 OR  -6
 TO CHANGE NODE CAPACITIES                     TYPE  7 OR  -7
 TO CHANGE TRAFFIC LOADS                       TYPE  8 OR  -8
 TO IMPLEMENT QUEUED PERTURBATIONS             TYPE       -99
 TO DELETE QUEUE                               TYPE 99
 TO TERMINATE DATA INPUT                       TYPE A BLANK
ENTER PERTURBATION OPTION
2
 * LINK DESTRUCTION: TYPE IN LINKS AS XX,XX,....
10,
 * LINK DESTRUCTION: TYPE IN LINKS AS XX,XX,....

 * LINK DESTRUCT: LINKS=  10

ENTER PERTURBATION OPTION
4
```

Figure 30. Sample Conversational Menu

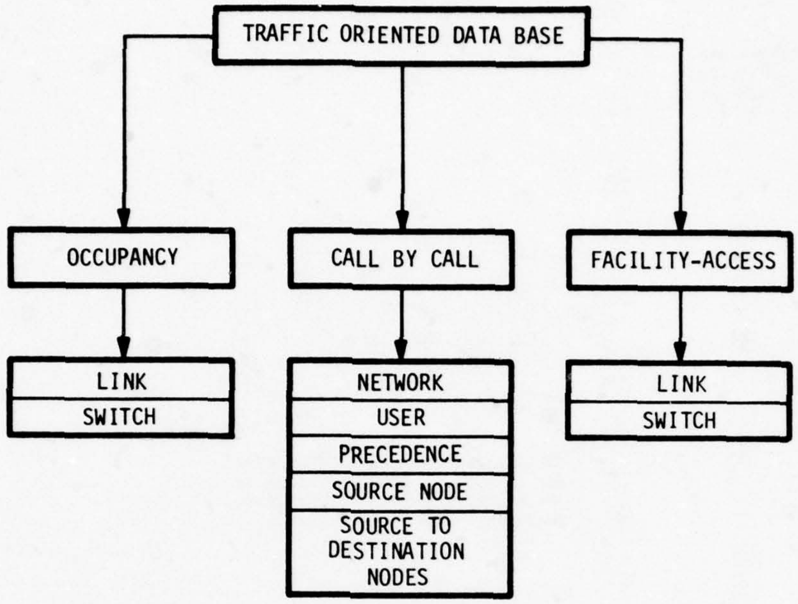


Figure 31. Traffic Oriented Data Base Structure

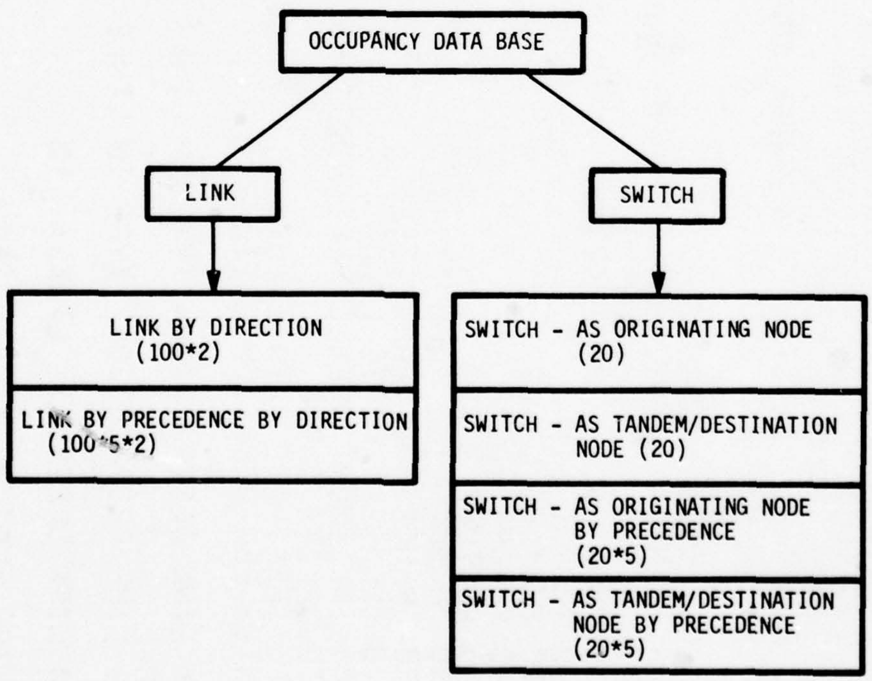


Figure 32. Elements of Occupancy Data Base

The link-associated elements relate the number of trunks (channels) occupied by direction, and by direction and precedence, for each link or trunk/group. Although occupancy by direction is implicitly contained in precedence by direction, both elements are maintained for efficiency of the routing algorithm. The nonprecedence values are used primarily for nonhostile routing attempts, and allow a rapid resource available or resource unavailable decision for normal and directionalized routing attempts. The precedence values that were added with the program conversion facilitate preemptive searches by eliminating futile preemptive attempts and attempts to find a lower-than-existing call for preemption.

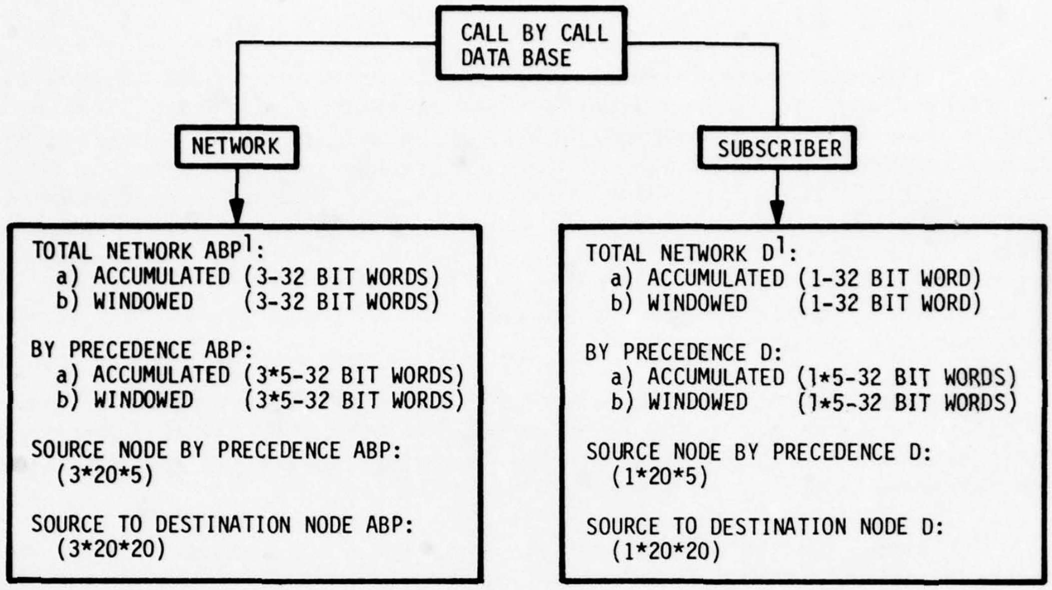
The switch associated elements tabulate switch occupancy as originating nodes and as tandem or destination nodes. As with the link occupancy elements, the precedence-associated elements have been added with the program conversion and relate principally to preemptive search efficiency.

The structure and elements of the call-by-call data base segment are illustrated in Figure 33. This segment is arranged to provide both network and subscriber statistics. The network-related elements are calls attempted (A), calls blocked (B), and calls preempted (P); while the subscriber element, calls denied access by the network (D), are used with ABP to represent statistics associated with the subscriber population. Those calls denied access by dial tone denial, for example, are assumed to be invisible to the network peg counters, and do not enter normally tabulated network statistics. As indicated in Figure 33, certain statistics are maintained for both accumulated and windowed values to permit automatic windowing for periodic data base transfer or display generation. All elements of the call-by-call data base, however, may be manually or periodically reset; although without the double tabulation, previously tabulated values are lost to further processing or display. The primary function of the call-by-call data base is to provide statistical data for performance index computation and for statistically oriented controller displays.

The facility access data base segment, illustrated in Figure 34, registers attempts, blockages, and preempts on interswitch links and switch facilities. The attempts and blockages reflect routing disposition of access attempts at specific facilities, and a single call may register attempts and blockage on multiple links and switches. A single call may also multiply peg attempts or blockages on given links and switches if both friendly and hostile attempts are made, and/or with certain possible alternate route configurations.

1.5.3 Display Module

The currently available display options are divided into four categories, as illustrated in Figure 35. Significant modifications have been implemented in the stripplot and controller position categories since the last contract. Routing table display options are added for the controller position callout. These three categories are described in the following subsections. The graphic options of the simulator have not been significantly altered to date, but proposed enhancements of particular graphic displays are considered in section 1.3. Discussion of this category is excluded here.



[1]A CALLS ATTEMPTED
B CALLS BLOCKED
P CALLS PREEMPTED
D SUBSCRIBER ATTEMPTS DENIED ACCESS BY NETWORK

Figure 33. Elements of Call-by-Call Data Base

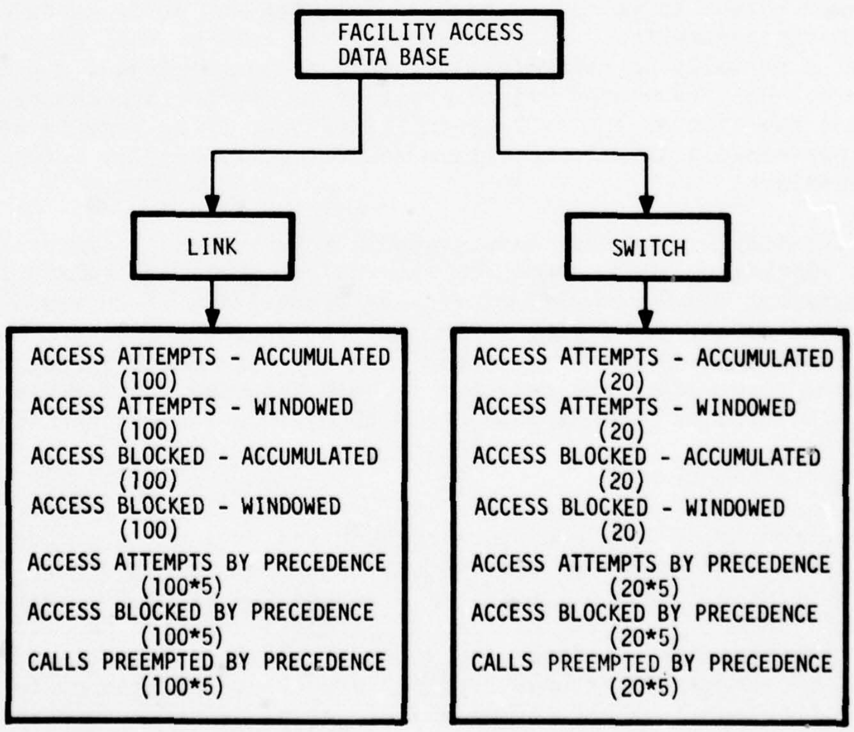


Figure 34. Elements of Facility Access Data Base

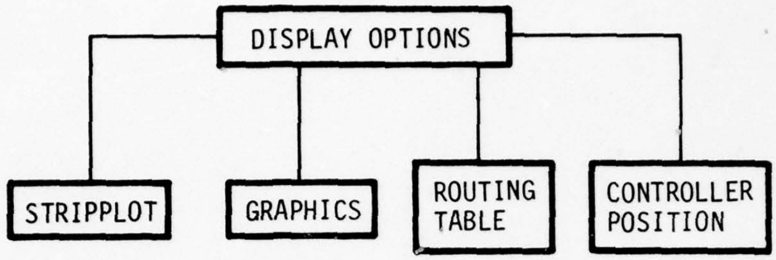


Figure 35. Simulation Display Options

1.5.3.1 Stripplot Display Options

A significant enhancement of the stripplot options has been implemented specifically for remote terminal operation. This feature allows the operator to interactively select which and what type stripplot displays to view on his available stripplot channels. The operator now has complete freedom of selection and placement prior to and during simulation runs. Table 3 details the currently available stripplot display options. Here the present utilization figures represent the ratio of occupied trunks to total trunk capacity. The GOS figures are computed as the ratio of blocked calls-to-calls attempted over the interval of interest. Accumulated figures represent values accumulated from time zero or since the last general data base reset command, while windowed values are computed from data registered in the current window interval. The link and node values are nominally accumulated from the last general data base reset or link and node data base reset command. It is noted that the simulation operator/controller may manually window or reset data bases at any time.

TABLE 3. STRIPPLOT OPTIONS

Type	Description
1	Link percent utilization
2	Link GOS - accumulated
3	Link GOS - windowed
4	Node percent utilization
5	Node GOS - accumulated
6	Node GOS - windowed
7	Network GOS - accumulated
8	Network GOS - windowed
9	Precedence GOS - accumulated
10	Precedence GOS - windowed

1.5.3.2 Routing Table Displays

The operator/controller may now interactively query current routing table status. Previously, this was an off-line option. Two formats are available for routing table display, as illustrated in Figures 36 and 37. The operator may select a portion of the routing table to be displayed by specifying a

```
***** 2: 0: 0*****
*NODE TO NODE ROUTING TABLE*
NS PTH    ND1S  ND2S  ND3S  ND4S  ND5S  ND6S  ND7S  ND8S  ND9S  ND10S ND11S
 6   1     2:1   2:1   3:1   8:1   8:1   0:0   8:1   8:1   2:1   8:1   8:1
     2     3:1   0:0   8:1   2:1   2:1   0:0   3:1   3:1   8:1   3:1   2:1
     3     0:0   0:0   0:0   3:1   3:1   0:0   0:0   0:0   3:1   0:0   3:1
     4     0:0   0:0   0:0   0:0   0:0   0:0   0:0   0:0   0:0   0:0   0:0
```

Figure 36. Node-to-Node Routing Table for Node 6

```
***** 2: 0: 0*****
*ROUTING TABLE FOR NODES *NS* TO *ND* WITH TANDEM PATH NODES *NTI**
*AND SPILL INDICATORS *SI* FOR PATHS *I**
NS ND   NT1:S   NT2:S  NT3:S  NT4:S
 3  4    4:1     8:1
 3  5    5:1     8:1
 4  3    3:1     8:1
 4  5    8:1     3:1
 5  3    3:1     8:1
 5  4    8:1     3:1
```

Figure 37. Alternate Routing Table Format Showing Interconnectivity of Nodes 3 Through 5

range of source nodes and range of destination nodes. Default values display the whole routing table. Figure 36 is an example of a complete routing table associated with a single node, while Figure 37, in a different format, shows all routes interconnecting nodes 3 through 5. The operator may direct the routing table listing to any of his assigned output devices, or may accept the default device. The default device for the remote terminal user is normally the remote Tektronix terminal.

1.5.3.3 Controller Position Displays

Many controller position displays are reformatted, and several new displays added. Previously, many displays presented both network and subscriber statistics, where subscriber statistics include calls denied access, and therefore unrecognized, by the network. Since the true subscriber statistics are normally unavailable to the network controller but are significant to network performance evaluation, these dual displays have been reformatted as separate displays. The currently available displays are listed in Table 4. Samples of these displays are presented in Appendix A. All these displays may be interactively requested. Requests may specify complete displays or portions thereof and be directed to any output device currently assigned to the CON task. Although all current displays are nominally derived from accumulations of statistics from time zero, the operator/controller may selectively or generally reset the statistical data base to provide displays for specific time intervals. Figure 38 presents a typical $ABCPGG_P$ display format, where A is attempts made, B is attempts blocked, C is attempts completed (C=A-B), P is calls preempted, G is GOS=B/A, and G_p is preemption rate, G_P=P/C. C, G and G_P are values computed from the raw data base values, A, B, and P. In the case of subscriber statistics displays, A and B include calls denied access to the network through dial tone denial.

1.5.4 Control and Scenario Modules

The control and scenario modules were updated for the multitask interactive simulator. The input/output structures of these two modules are now identical. To facilitate interactive simulation in faster than real time, an event queueing algorithm has been implemented. The controller/operator can now define series of control or scenario events and queue them for simultaneous implementation and thus avoid an unintentional skewing effect from real-time input delays and faster than real-time network simulation. Additional control and scenario capabilities are added. Table 5 summarizes the current menu of control options and levels at which they can be effectively utilized. Destination code cancellation can now be directed at a single source node, whereas previously the specified destination nodes were cancelled for all sources. The option to force primary only routing or to limit alternate routes at a node, group of nodes, or theater-wide has been implemented. The option is also available to restore the routing tables to a node, group of nodes, or theater-wide.

Table 6 lists the current scenario options. The only significant change to these options is with the traffic load scenario. This option has been made more flexible by allowing the operator to specify single or groups of source and destination modes and single or intervals of precedence level to be effected. "All nodes" and "all precedences" are default options.

TABLE 4. CONTROLLER POSITION DISPLAYS

Network Displays	
a) $ABCPGG_p$*	- Total Network
b) $ABCPGG_p$	- By precedence
c) $ABCPGG_p$	- By source node
d) $ABCPGG_p$	- By source node and precedence
e) $ABCPGG_p$	- By source and destination nodes
Subscriber Displays	
a) $ABCPGG_p$	- Total subscriber community
b) $ABCPGG_p$	- By precedence
c) $ABCPGG_p$	- By source node
d) $ABCPGG_p$	- By source node and precedence
e) $ABCPGG_p$	- By source and destination nodes
Link	
a) Occupancy/capacity	
b) Occupancy by direction and precedence with capacity	
c) Accumulated link/priority GOS status with threshold alarms	
d) Accumulated link/priority preemption status with threshold alarms	
Switch	
a) Occupancy/capacity	
b) Occupancy by direction and precedence with capacity	
c) Accumulated node/priority GOS status with threshold alarms	
d) Accumulated node/priority preemption status with threshold alarms	

* Figure 38 presents a typical $ABCPGG_p$ display.

***** 0:30: 0*****

ACCUMULATED NODE TO NODE NETWORK STATISTICS

NODE	NODE	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	NODE	NODE
4	1	210	34	176	35	0.1619	0.1989	4	1
5	1	65	11	54	12	0.1692	0.2222	5	1
6	1	68	12	56	17	0.1765	0.3036	6	1
7	1	26	5	21	9	0.1923	0.4286	7	1
8	1	184	27	157	49	0.1467	0.3121	8	1
4	2	6	0	6	0	0.0000	0.0000	4	2
5	2	1	0	1	0	0.0000	0.0000	5	2
6	2	6	0	6	0	0.0000	0.0000	6	2
8	2	9	0	9	1	0.0000	0.1111	8	2
4	3	83	1	82	8	0.0120	0.0976	4	3
5	3	13	0	13	0	0.0000	0.0000	5	3
6	3	5	0	5	0	0.0000	0.0000	6	3
7	3	13	0	13	0	0.0000	0.0000	7	3
8	3	60	2	58	3	0.0333	0.0517	8	3
5	4	15	0	15	0	0.0000	0.0000	5	4
6	4	13	0	13	0	0.0000	0.0000	6	4
7	4	23	0	23	0	0.0000	0.0000	7	4
8	4	52	0	52	0	0.0000	0.0000	8	4
4	5	7	0	7	0	0.0000	0.0000	4	5
8	5	10	0	10	0	0.0000	0.0000	8	5
4	6	26	0	26	0	0.0000	0.0000	4	6
5	6	1	0	1	0	0.0000	0.0000	5	6
7	6	7	0	7	0	0.0000	0.0000	7	6
8	6	18	0	18	2	0.0000	0.1111	8	6
4	7	17	0	17	0	0.0000	0.0000	4	7
5	7	1	0	1	0	0.0000	0.0000	5	7
6	7	2	0	2	0	0.0000	0.0000	6	7
8	7	13	0	13	0	0.0000	0.0000	8	7
4	8	42	0	42	0	0.0000	0.0000	4	8
5	8	18	0	18	0	0.0000	0.0000	5	8
6	8	70	5	65	3	0.0714	0.0462	6	8
7	8	39	0	39	0	0.0000	0.0000	7	8
4	9	19	0	19	0	0.0000	0.0000	4	9
5	9	5	0	5	0	0.0000	0.0000	5	9
6	9	14	0	14	0	0.0000	0.0000	6	9
7	9	8	0	8	0	0.0000	0.0000	7	9
8	9	8	0	8	0	0.0000	0.0000	8	9
4	10	12	0	12	0	0.0000	0.0000	4	10
5	10	7	0	7	0	0.0000	0.0000	5	10
6	10	7	0	7	0	0.0000	0.0000	6	10
7	10	4	0	4	0	0.0000	0.0000	7	10
8	10	6	0	6	0	0.0000	0.0000	8	10
4	11	7	0	7	0	0.0000	0.0000	4	11
5	11	4	0	4	0	0.0000	0.0000	5	11
6	11	2	0	2	0	0.0000	0.0000	6	11
8	11	2	0	2	0	0.0000	0.0000	8	11

Figure 38. Typical ABCPGGp Display

TABLE 5. CONTROL OPTIONS AND EFFECTIVE LEVELS OF IMPLEMENTATION

Directive Option	Implementation Levels
a) Reset all controls to normal	Theater
b) Destination code cancellation (may be invoked by precedence)	Theater/Sector/Nodal
c) Line load control - access denial by precedence	Theater/Sector/Nodal
d) Link directionalization	Nodal
e) Link access restriction by precedence	Nodal
f) Primary only or limited alternate routing	Theater/Sector/Nodal
g) Alter routing table	Nodal
h) Restore nominal routing tables	Theater/Sector/Nodal
i) Reassign link or switch capacities	Sector/Nodal

TABLE 6. SCENARIO OPTIONS

a) Reset all perturbations	
b) Remove links	(Complete destruct)
c) Remove nodes	(Complete destruct)
d) Alter link capacity	(Partial destruct)
e) Alter node capacity	(Partial destruct)
f) Restore links	(To nominal status/capacity)
g) Restore nodes	(To nominal status/capacity)
h) Alter traffic levels	(Local/general, all priorities/ by precedence)

1.6 Conclusions and Recommendations

During the first 9-month period of the contract, preliminary analyses of near-term DCS requirements have been conducted. These analyses have included an assessment of near-term DCS configuration and requirements, ACOC network controller functions, and information flow. Recommendations from these analyses are contained in sections 1.2.4 and 1.3 and include TDCS upgrades, data base requirements, and controller aids.

TDCS recommendations include an interactive controller interface, multiplexed data gathering, periodic traffic data reporting on a continuous basis, and selection of reported data. Data base upgrades include increased processing and refinement of data at lower levels, use of dedicated lines for data gathering, and incorporation of ATEC, ACAS, and TDCS data into a common data base. Controller aid recommendations include interactive menus, graphics terminal displays (alarm isolation, bar charts, and topological plots), and network simulator models.

The controller interactive scenarios (section 1.4) illustrating satellite capacity reallocation, routing updates, and channel reassignment in the European AUTOVON demonstrate the value of the interactive network simulator in evaluation of system control techniques. The modifications to the simulator completed during this phase of the contract provide extended capabilities necessary to perform network studies during the second phase of this contract.

2.0 TRANSMISSION SYSTEMS SIMULATION

Section 2.0 of this report documents results and progress of the transmission system simulations and software support for the first 9 months of contract DCA 100-77-C-0061. Hybrid computer models for two complex digital modems have been designed, a line-of-sight flat fading Rayleigh and frequency selective fading trospospheric scatter channel simulator mechanized on a hybrid computer, and remote user interactive configuration change, data reduction, and graphic display programs designed and validated.

The two digital transmission and receiving systems modeled on the hybrid computer are the Distortion Adaptive Receiver (DAR) and the Quadraphase Partial Response (QPR). These represent troposcatter and line-of-sight techniques, respectively. The DAR has been simulated in its entirety except for the adaptive equalizer. Checkout and validation of the DAR has been completed for noise and Rayleigh fading. The system has been validated by measuring bit error performance over an operational range of signal-to-noise ratios. The line-of-sight technique, QPR, has been programmed and is in the initial stage of checkout.

Fading models for frequency flat and selective fading are currently operational, but further validation tests are required before the selective fading can be used in the troposcatter modem studies. These tests include validation of frequency flat facing for each pair of taps of the four simulated troposcatter channels. Some of these tests have been performed and are included in section 2.2.

The supportive software development includes programs to operate the DAR transmission system simulation from a remote hybrid terminal at the Defense Communications Engineering Center (DCEC), to display performance and test variables on the graphics terminal, and to perform on-line and off-line data analysis of performance variables. Similar programs will be developed for other transmission systems to be simulated during this contract by modifying the DAR programs. Progress on these programs is discussed in section 2.5.

During the past 9 months, programming of the frame synchronization techniques has commenced. Programs for both transmit and receive sides have been developed and checked open loop. These programs are discussed in section 2.4 and include the display of pertinent synchronization variables.

2.1 Digital Troposcatter Modem Simulation

The DAR digital troposcatter modem simulation includes a time-gated quadrature phase shift keyed (QPSK) transmitter and quad diversity matched filter receiving system. A system functional flow block diagram is shown in Figure 39. The transmission system includes serial-to-parallel conversion and differential encoding of the digital bit stream. The resulting encoded parallel data sequences drive the in-phase and quadrature modulators to obtain the QPSK modulated signal. Spectrum control filters and

a nonlinear amplifier follow the QPSK modulator. Each of the four diversity receivers is composed of a coherent carrier recovery loop and matched filter demodulation technique. The reference IF carrier is obtained by using re-modulation and coherent filter techniques to extract a clean unmodulated carrier in the likeness of the received transmitted signal. Recovered base-band signals of the four diversity receivers are summed, integrated and dumped, and decoded to produce the received version of the transmitted digital signal. The following paragraphs describe the simulation of each element comprising the DAR transmit and receive systems.

2.1.1 Simulation Time Scale

To simulate the functions of an actual microwave transmission and receiving system on a hybrid computer requires a time and frequency scaling of each element of the system. For the DAR a convenient scale factor of 7000 has been selected. Both baseband and IF elements in the model are scaled by this factor. For example, the DAR transmitter reference oscillator at 70 MHz is simulated at a scaled frequency of 10 kHz. The scaled bit rate is 1 kHz which corresponds to an actual bit rate of 7 Mb/s.

2.1.2 DAR Data Input and Transmitter Simulation

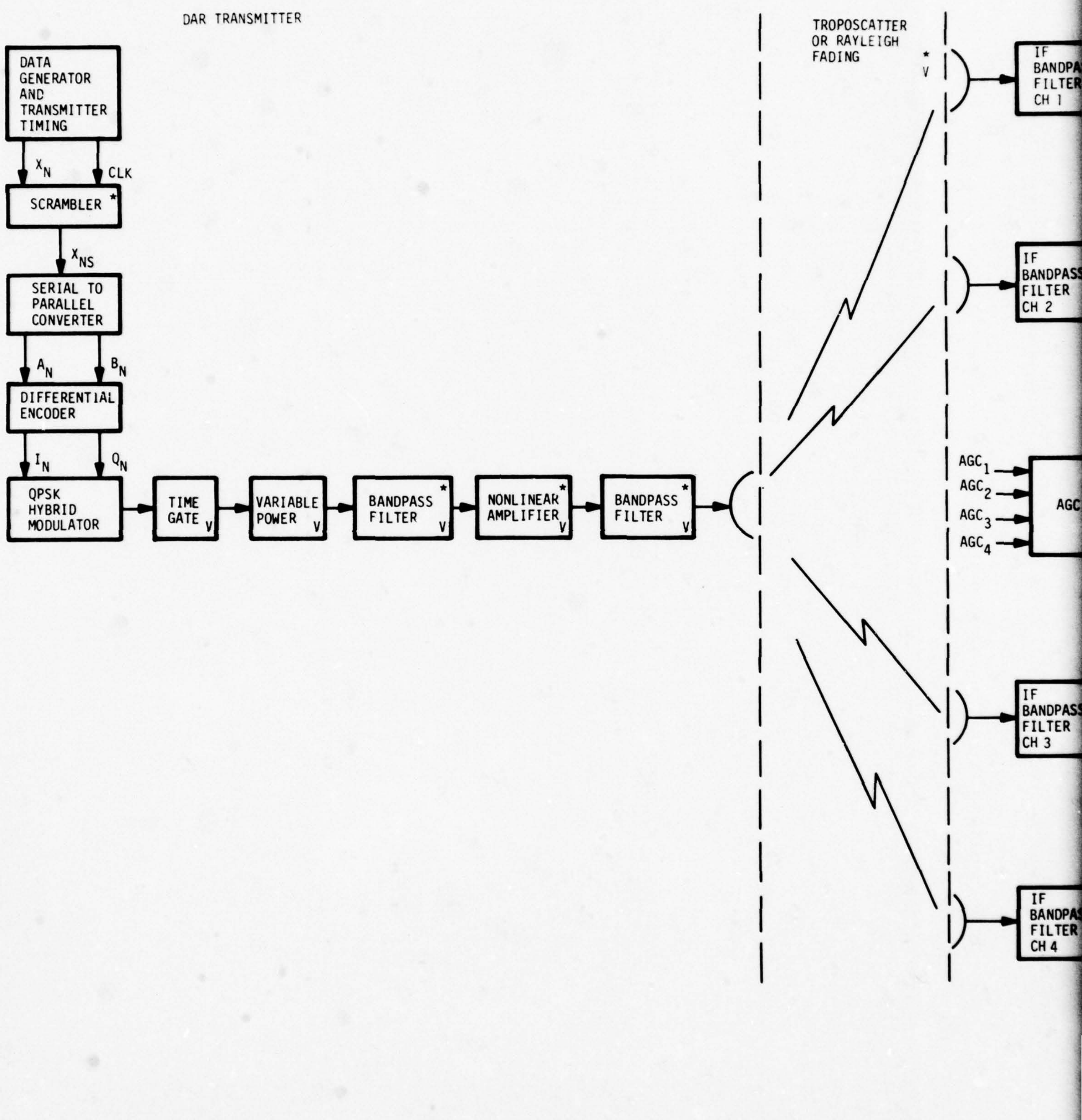
The simulated data input and transmitter sections include data generator, serial-to-parallel converter, differential encoder, 4-phase phase shift keyed (PSK) modulator, and variable time gate. Optional modules include two bandpass filters for limiting the transmitted spectrum, a nonlinear amplifier (AM/AM and AM/PM) conversion, and data scrambler. Figure 39 shows these elements and notes the variable and optional elements.

To generate a digital serial multiplexed bit stream, a Gaussian noise source is sampled using a simulated transmitter clock and analog track and store amplifier. The transmitter clock is derived from the transmit reference oscillator by programming a down counter with the count set to 10. This generates a bit rate clock of 1 kHz in phase with the reference carrier at 10 kHz. The resulting serial bit stream can be input to a 2-stage scrambler at the option of the user. Figure 40 illustrates the scramber mechanization using parallel logic components of the hybrid computer. The scrambled data is generated by modulo 2 summing the unscrambled data X_n and the 2-bit delayed modulo 2 sum output Y_{n-z}. A serial-to-parallel converter follows the scrambler. This process is simulated by retiming the data with the symbol clock (one-half the frequency of the bit rate clock, 500 Hz simulated and 3.5 Mbs actual) using flipflops on the parallel logic patchboard of the computer. Both serial-to-parallel conversion and differential encoding functions are shown in Figure 41. The simulated differential encoding function is

$$A^*_n = A^*_{n-1}B^*_{n-1}B_n + A^*_{n-1}\overline{B}^*_{n-1}A_n + \overline{A}^*_{n-1}B^*_{n-1}\overline{A}_n + \overline{A}^*_{n-1}\overline{B}^*_{n-1}\overline{B}_n$$

$$B^*_n = A^*_{n-1}B^*_{n-1}A_n + A^*_{n-1}B^*_{n-1}\overline{B}_n + \overline{A}^*_{n-1}B^*_{n-1}B_n + A^*_{n-1}B^*_{n-1}\overline{A}_n$$

* represents encoded data.


DAR TRANSMITTER
TROPOSCATTER OR RAYLEIGH FADING
DATA GENERATOR AND TRANSMITTER TIMING
X_N
CLK
SCRAMBLER *
X_{NS}
SERIAL TO PARALLEL CONVERTER
A_N
B_N
DIFFERENTIAL ENCODER
I_N
Q_N
QPSK HYBRID MODULATOR
TIME GATE V
VARIABLE POWER V
BANDPASS FILTER * V
NONLINEAR AMPLIFIER * V
BANDPASS FILTER * V
* V
IF BANDPA FILTER CH 1
IF BANDPASS FILTER CH 2
AGC_1
AGC_2
AGC_3
AGC_4
AGC
IF BANDPASS FILTER CH 3
IF BANDPAS FILTER CH 4

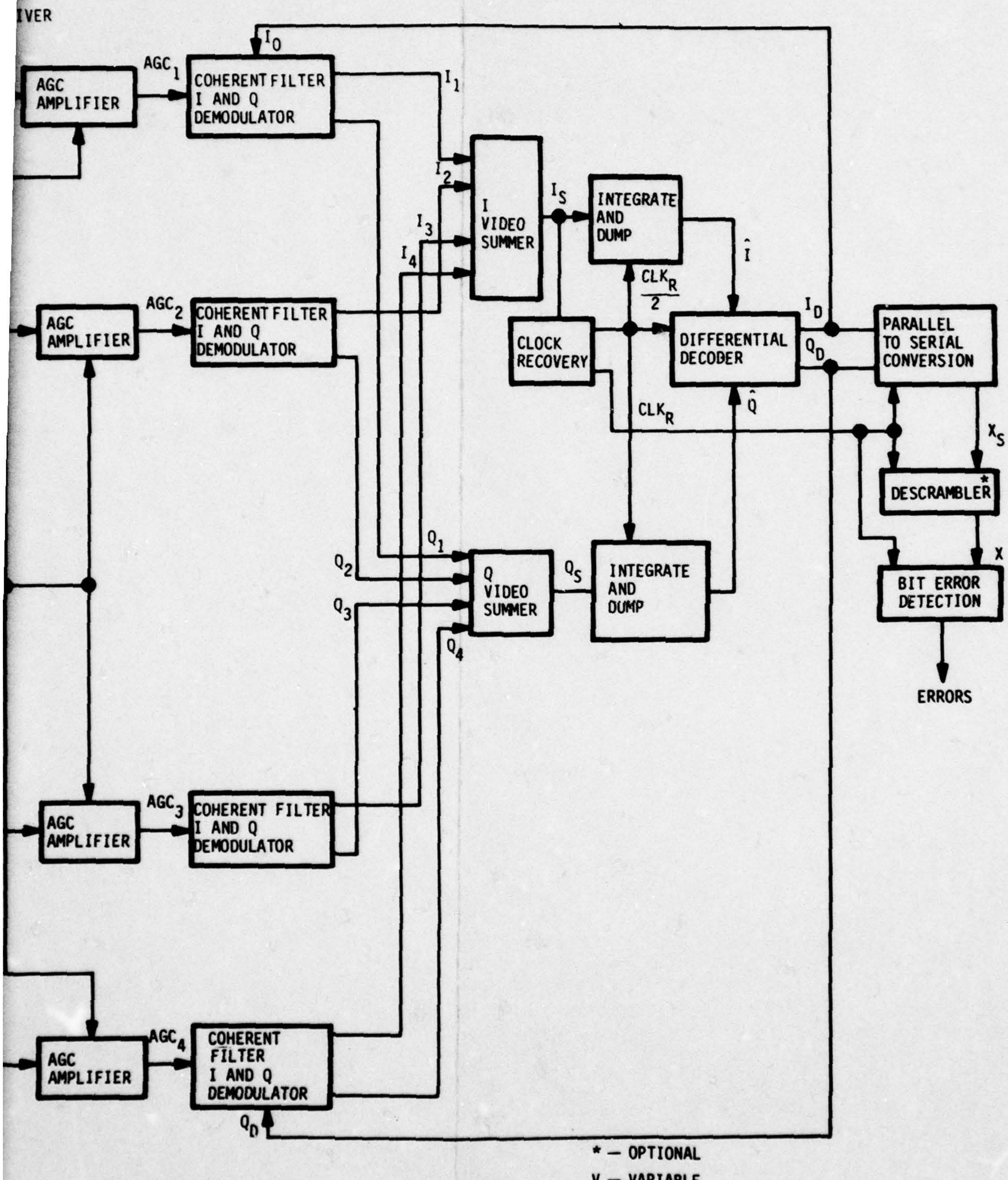


Figure 39. DAR Quad Diversity Troposcatter Simulation

2

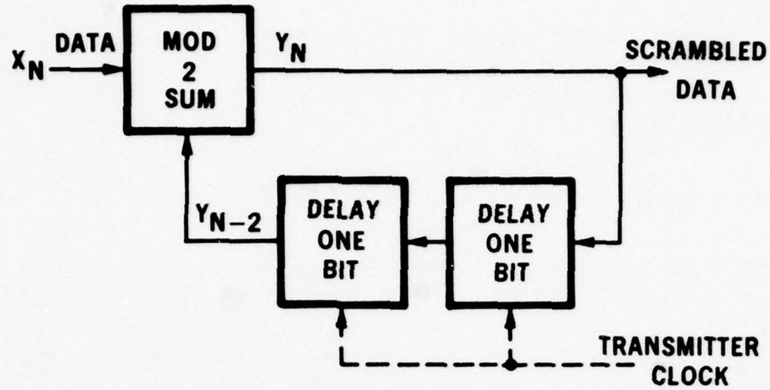


Figure 40. Data Scrambler

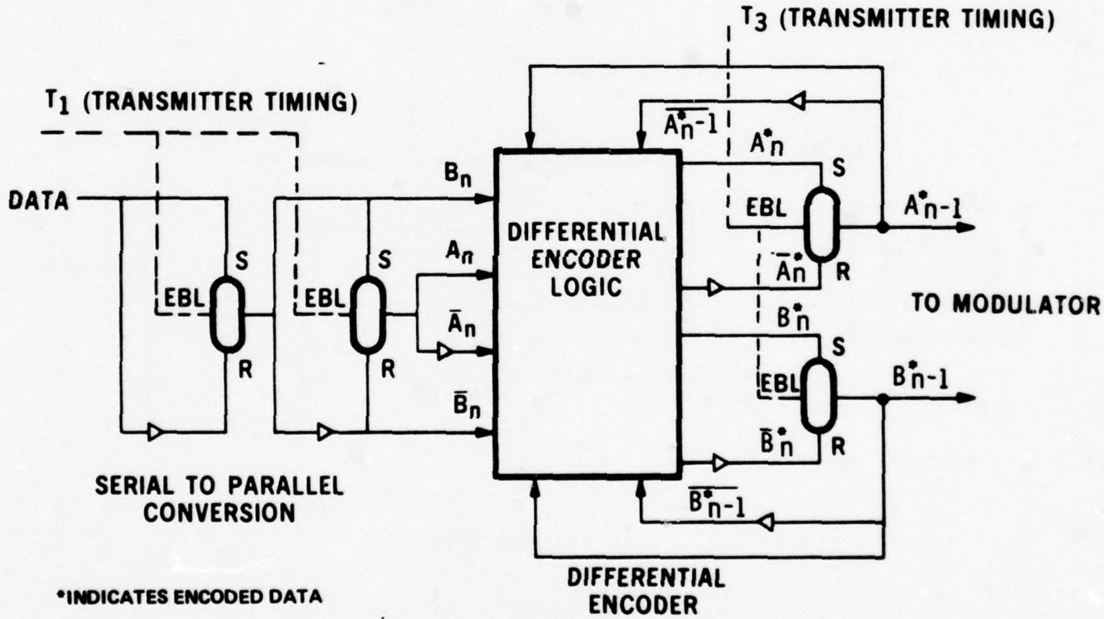


Figure 41. Serial-to-Parallel Conversion as Differential Encoder

Differential encoding is required to remove the data ambiguity that can occur at the QPSK receiver due to the phase of the coherent reference. The encoder is programmed using the parallel logic on the analog computer.

The QPSK modulator is mechanized as a hybrid element. A reference carrier is programmed on the analog computer and is both frequency and amplitude stabilized. Shifting to one of four possible phases is accomplished

by using the encoder logic signals to sum and difference the sine and cosine outputs of the reference oscillator to generate any of the four discrete phase states. These states are $\pi/4$, $3\pi/4$, $5\pi/4$, and $7\pi/4$. QPSK can be expressed analytically as

$$S(t) = \frac{1}{\sqrt{2}}[I(t) \text{ Sin } \omega_c t + Q(t) \text{ Cos } \omega_c t$$

where I(t) and Q(t) are parallel data sequences at the symbol rate and take on discrete values of ±1. Implementation of S(t) is shown in Figure 42.

A time gate is provided in the simulation to allow the analyst to specify the transmitter ON time during each symbol interval. The simulation user can specify a percent time gate (0 to 100) which is used to compute an ON time count. This ON count is then loaded into a 4-bit register that controls the closure of an electronic switch.

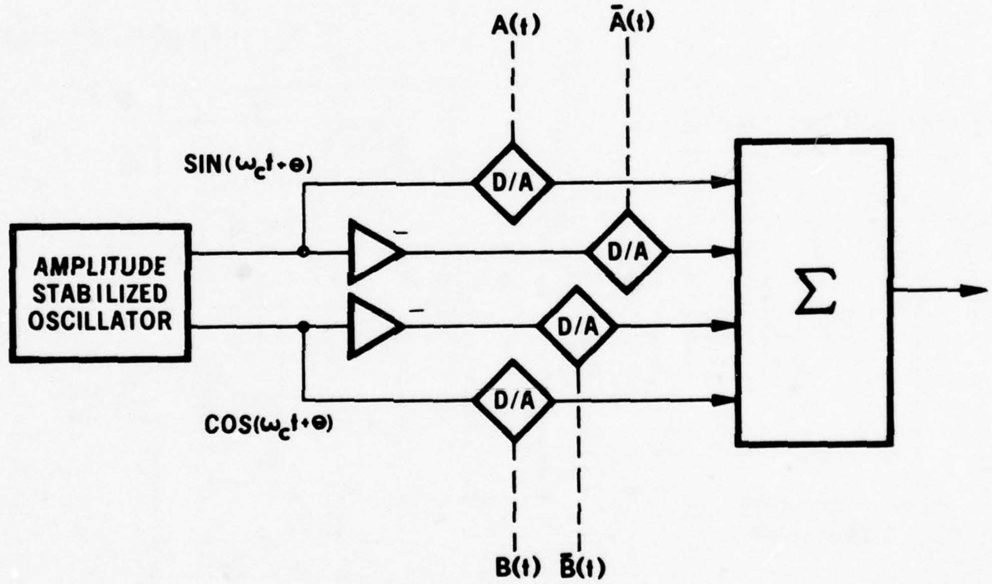
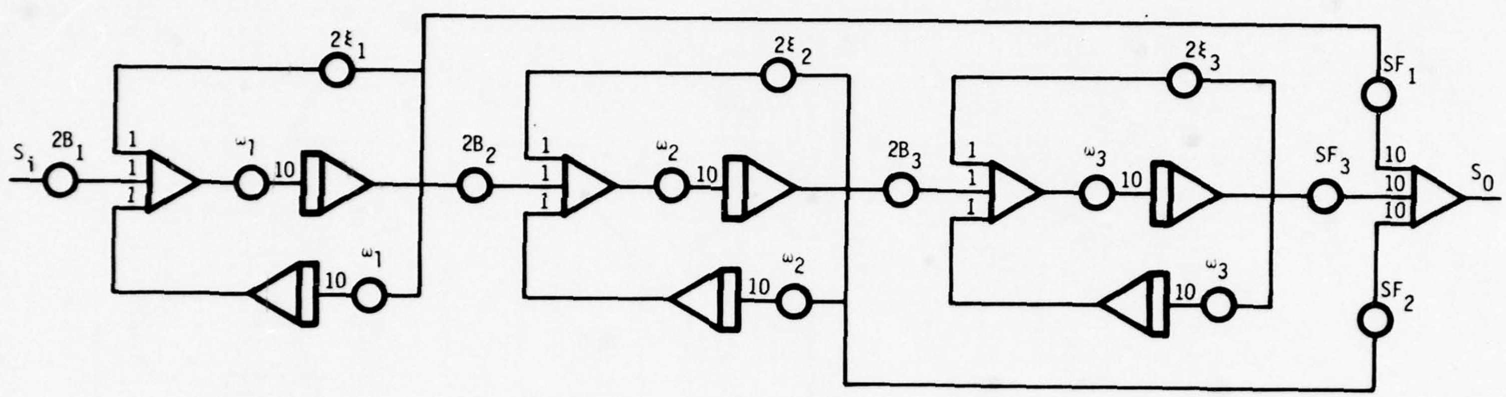


Figure 42. QPSK Modulator

Optional spectrum control bandpass filters are simulated following the QPSK modulator and optional nonlinear amplifier. Currently these filters can be programmed from the remote terminal at DCEC to reflect either Butterworth or Chebyshev characteristics for two, four, or six poles. Each filter is mechanized as shown in Figure 43. This filter programmed on the analog computer is controlled digitally by the simulation user. A stagger tuned approach is taken where the parameters for each stage are calculated and set by the digital computer. Briefly, each second order stage is tuned to a particular center frequency and bandwidth to achieve the overall filter characteristic desired. A more detailed explanation of these programs is included in section 2.5.



SIMULATES SECOND, FOURTH, OR SIXTH ORDER
CHEBYSHEV, BUTTERWORTH, OR BESSEL BANDPASS FILTER.

Figure 43. Bandpass Filter Simulation

Referring to Figure 43, the parameters β, ξ, and ω of each stage represent the gain bandwidth product, bandwidth, and center frequency respectively. SF_1, SF_2 and SF_3 are scale factors that adjust the gain through the complete filter and select the order of the filter.

Included in the transmission system between the two bandpass filters is a nonlinear device which can simulate the AM/AM and AM/PM characteristics of TWT and Klystron amplifiers. Figure 44 illustrates the simulation of this function using analog computing elements and card programmed diode function generators. The modulated carrier is input to an envelope detector which determines the time-varying amplitude of the carrier by diode-detecting the signal magnitude and filtering out the carrier frequency. This amplitude function output of the envelope detector drives two function generators that are programmed with the AM/AM and AM/PM characteristics of a given nonlinear device. The output of the AM/PM function generator determines the time constants for an analog computer programmed phase shifter that then shifts the modulated carrier by the computed phase angle. The AM/AM function generator drives a gain circuit that multiplies the modulated carrier by the corresponding gain.

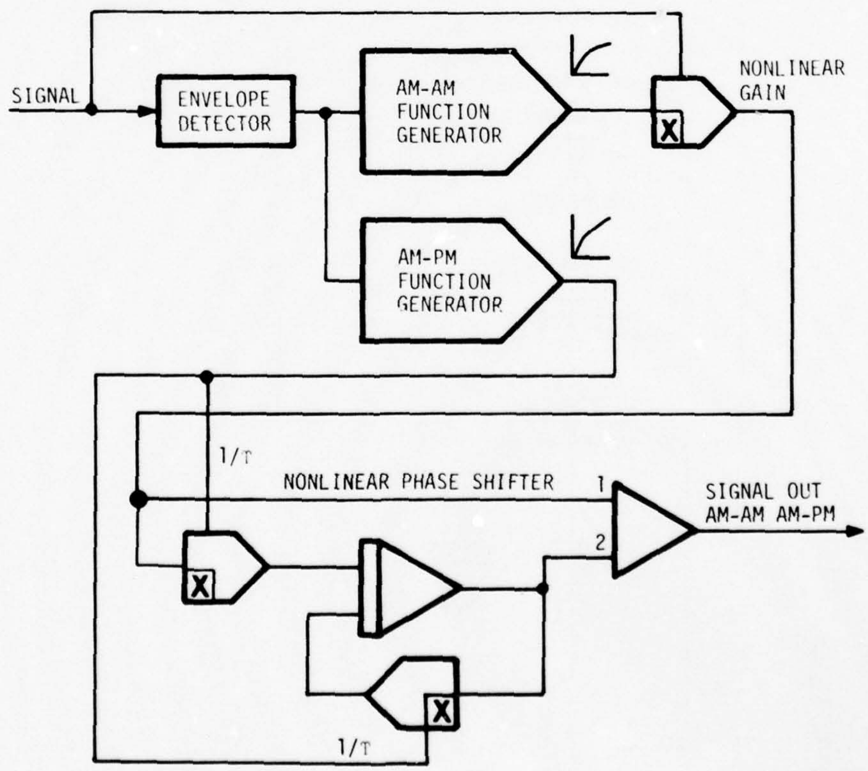


Figure 44. Nonlinear Device Implementation

2.1.3 DAR Receiver Simulation

The distortion adaptive diversity receiver simulation includes four identical receivers combined at a video summer before decoding and regenerating the received digital data. Major elements of each receiver are the IF section (bandpass filter and AGC), I and Q demodulator, and coherent filter. The common data regeneration circuit includes a video summer, integrate and dump, differential decoder, parallel-to-serial converter, and an optional 2-bit descrambler. A simulated early/late gate digital phase-lock loop clock recovery system provides bit and symbol timing for the data regeneration circuits.

Four identical IF sections are programmed on the analog computer to simulate the IF bandpass filters and AGC characteristics of the DAR. Filters for these sections are programmed identically to those used for controlling the transmitted spectrum (see section 2.1.2). The simulation user may specify either Butterworth or Chebyshev type filters, and choose 2-, 4-, or 6-pole filters of either type, specifying bandwidth, center frequency, number of poles, and ripple factor (Chebyshev only). Figure 45 illustrates the mechanization of the four IF sections and their AGC circuits. Each simulated IF section computes an AGC gain that is input to an AGC select circuit which determines the highest received signal level (RSL) or lowest AGC gain and makes this gain common to all four AGC amplifiers. Outputs of the four IF filters are input to individual demodulator circuits.

Figure 46 is a block diagram of one of the four demodulators simulated for the DAR. Programming diagrams of these dedulators and other elements of the DAR are included in Appendix D of this report. The DAR demodulator is one of the more difficult elements to simulate on an analog computer because of the 1-baud delays required in the IF and coherent filter signal paths. This problem was solved by using analog charge coupled devices (CCD) to build a sample-and-hold delay device for each of the eight 1-baud delays required, two per demodulator. A more detailed description of the implementation of these devices in delay line applications is given in section 2.3. A description of the simulation of one of the four demodulators follows.

Referring to Figure 46, the IF signal is input to the in-phase and quadrature multipliers and a 1-baud delay CCD device. This delayed signal is remodulated or inverse modulated by the decoded symbols I and Q of that interval to provide an unmodulated carrier to the input of the coherent filter. The coherent filter simulation is a positive loop which delays the summation of the in-phase and quadrature components of the demodulator and output of the 1-baud delay multiplied by a gain of less than one. This loop has a recirculatory action that coherently adds previous distorted pulses to the present pulse while noise is incoherently added. An adjustment analog delay circuit also is programmed into the coherent loop to fine tune the CCD delay. The coherent reference present at the summer is multiplied with the undelayed IF signal to generate the in-phase and quadrature video signals. Both the in-phase and quadrature signals are low-pass filtered to remove spurious components before summing with the other diversities at the video summer. These video sums, in-phase (I) and quadrature (Q), of all diversity

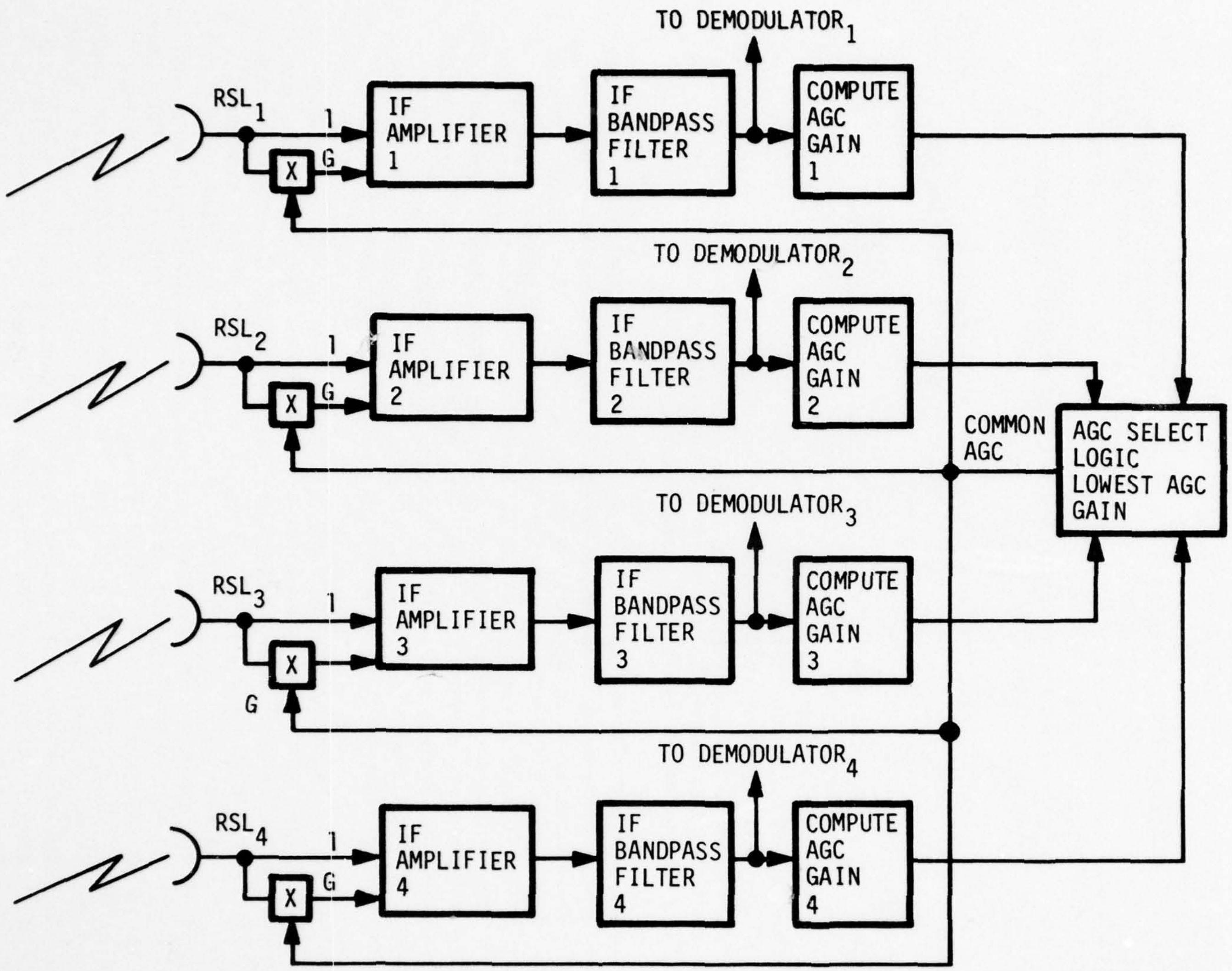


Figure 45. Troposcatter Modem IF and AGC Model

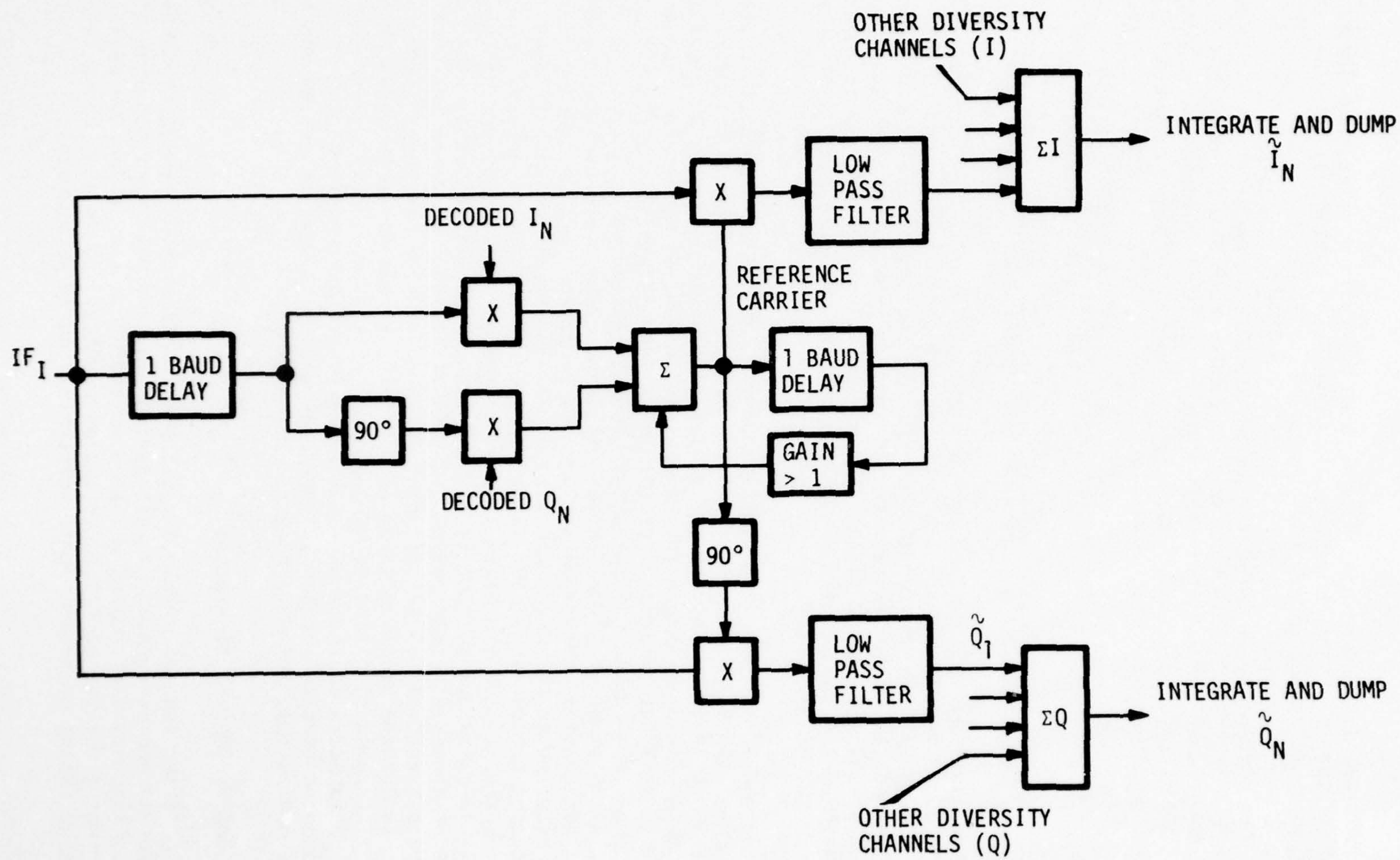


Figure 46. DAR Demodulator and Coherent Filter

channels are integrated over each symbol interval, sampled, and dumped. Synchronization of the integrate and dump analog circuit is provided by the simulated bit timing recovery circuit.

The next phase of the DAR simulation is data regeneration which is shown in Figure 47. Data regeneration begins with the in-phase and quadrature samples of the analog integrate and dump. These samples are input to a differential decoder which is programmed using hybrid computer parallel logic. Equations for the decoder are

$$a_n = a^*_{n-1} b^*_{n-1} b^* + a^*_{n-1} \overline{b}^*_{n-1} a^*_n + \overline{a}^*_{n-1} b^*_{n-1} \overline{a}^*_n + \overline{a}^*_{n-1} \overline{b}^*_{n-1} \overline{b}^*_n$$

$$b_n = a^*_{n-1} b^*_{n-1} a^*_n + a^*_{n-1} \overline{b}^*_{n-1} \overline{b}^*_n + \overline{a}^*_{n-1} b^*_{n-1} b^*_n + \overline{a}^*_{n-1} \overline{b}^*_{n-1} \overline{a}^*_n$$

The resultant decoded digital symbol streams, (a_n, b_n) are parallel-to-serial converted by gating of the a_n and b_n signals with the gate and sample clock pulses derived from the receiver clock. If the bit stream is scrambled at the transmitter, a descrambler is selected to inverse this process to obtain the serial received digital bit stream. The received and transmitted bit streams are then tested using an exclusive OR logic circuit to detect bit errors.

An early/late gate bit timing recovery circuit is simulated to provide the symbol and bit timing to the data regeneration circuits. This simulation, shown in Figure 48, models a digital phaselock loop (PLL) technique. To simulate this technique the demodulated baseband, I, at the video sum is sliced and differentiated to provide data transitions to the clock recovery early and late counts. A reference clock is simulated on the analog computer at 64 times the symbol rate. As transitions are detected, the AND gates and counters determine whether the receiver clock is running slow or fast relative to the data transitions. If the receiver clock is fast, a transition arrives while the clock is high and a count is entered into the upper register. If the clock is slow, a transition arrives during the complemented clock and a count is entered into the lower register. The center register counts all transitions. The first register to reach its full count resets all registers. If the upper register reaches its count first, a pulse is deleted from the input to the receiver clock countdown and the receiver clock is slowed by $2\pi/64$ radians. If the lower count is reached first, a pulse is added to the input of the receiver clock countdown and the clock is advanced by $2\pi/64$ radians. The clock output is used to derive the sample, gate, descramble, and dump pulses.

2.2 Fading Channel Simulation

A fading channel simulation using a combination of hybrid computer technology and integrated circuit design has been developed for line of sight frequency flat fading and troposcatter frequency selective fading. By changing the tap coefficients (delay profile), up to four channels of Rayleigh fading or tropospheric scattering can be programmed.

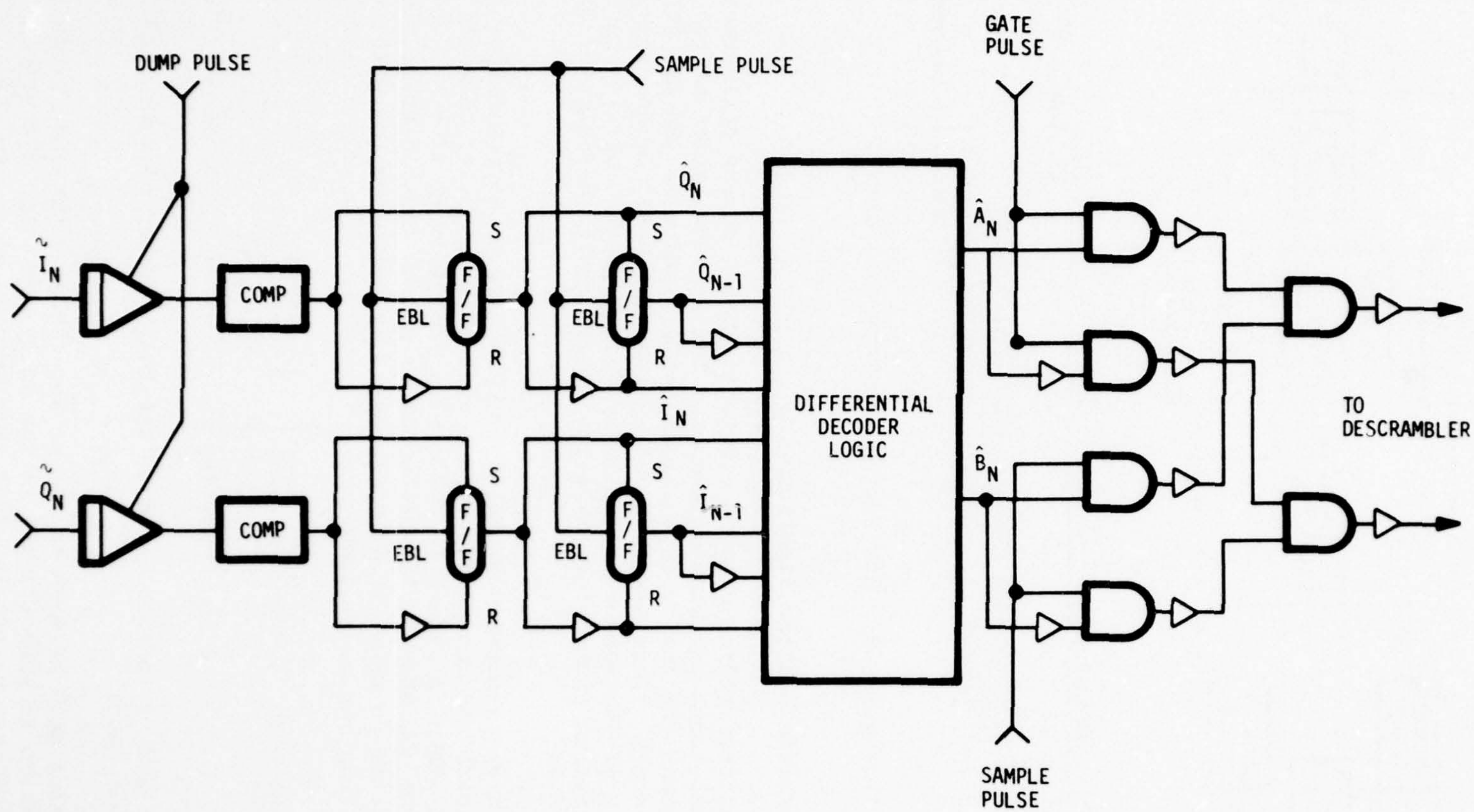


Figure 47. DAR Data Regeneration Simulation

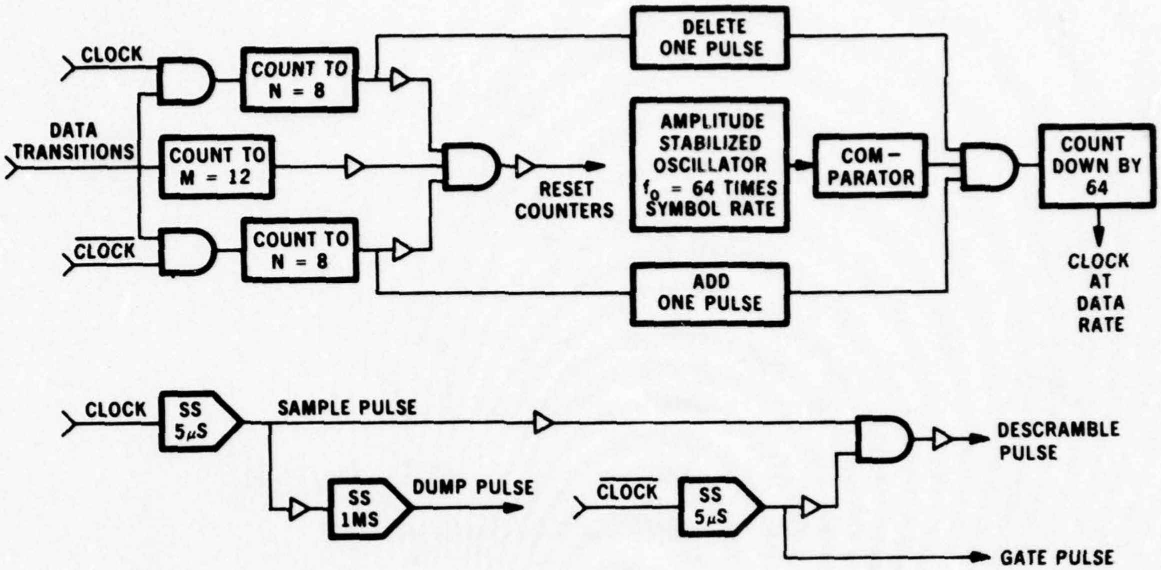


Figure 48. Bit Timing Recovery and Control

2.2.1 Tropospheric Scatter Simulation

A troposcatter fading channel simulation based on the Bello troposcatter channel model has been developed. The implementation of the model is unique in that the analog delay lines utilize state-of-the-art CCDs as the delay elements. This approach was chosen over more common digital techniques because of the inherent simplicity and the higher obtainable bandwidth. The devices chosen for the delay lines permit the delay of IF frequencies to 20 kHz.

The Bello troposcatter channel model provides an approximation to the average multipath and fading properties of the troposcatter channel. The channel model shown in Figure 49 utilizes a tapped delay line with taps at intervals of $\tau = 1/W$, where W is the bandwidth of the input signal. The output from each tap is multiplied by a complex Gaussian process with the following correlation properties:

$$G_i^*(t)\, G_j(t) = \begin{Bmatrix} \frac{Q(i,W)}{W} & \text{for } i=j \\ 0 & \text{for } i=j \end{Bmatrix}$$

where i and j are tap positions, n is the total number of taps, and Q is the delay power profile.

The complex gain of each tap is an uncorrelated Gaussian process, the variance of which is proportional to the delay power profile evaluated at the position of that particular tap. The outputs of the multipliers are

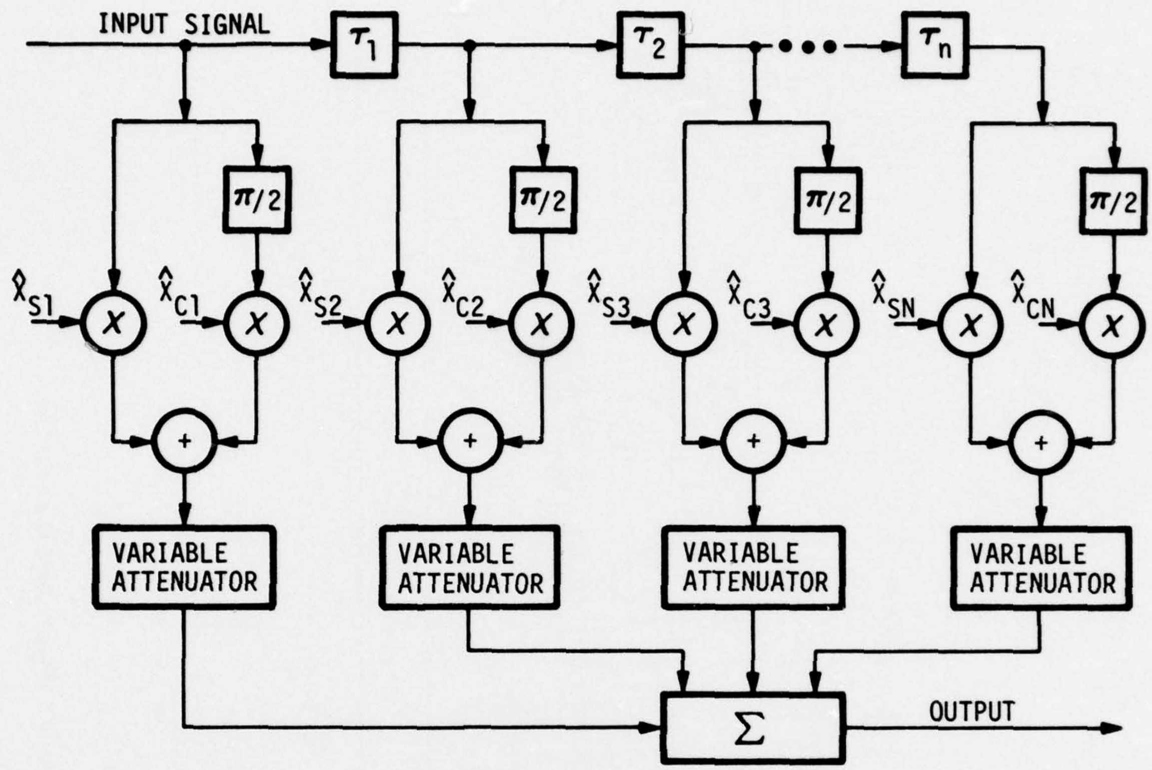


Figure 49. Troposcatter Channel Model

then summed to form the simulated channel output. Four such uncorrelated channels are programmed to allow detailed study of channel effects in diversity transmission systems.

The simulator is made up of three elements: a delay line module, a digital filter module, and a multiplier-summer module. The troposcatter simulation module allows the user to change the channel fade rate, signal-to-noise ratio, and path parameters. A block diagram of the simulated channel model is shown in Figure 50.

The delay line module is a special purpose device integrated into the hybrid computer system. It consists of CCD integrated circuits, interconnection and tap output filtering circuits, clocking circuits, and a power supply. The clock frequency was chosen to provide an appropriate delay between the taps. For the DAR application a 10 kHz signal with a bandwidth of 2 kHz and a clock frequency of 512 kHz gives a delay of 500 μs per tap (1/W) and 50 samples per cycle. Each tap output has been filtered to remove sampling noise. The channel simulator has two delay lines, each having up to 12 taps. Delay line 1 is the in-phase tapped delay line, while the quadrature delay, line 2, contains an additional $\pi/2$ at each tap.

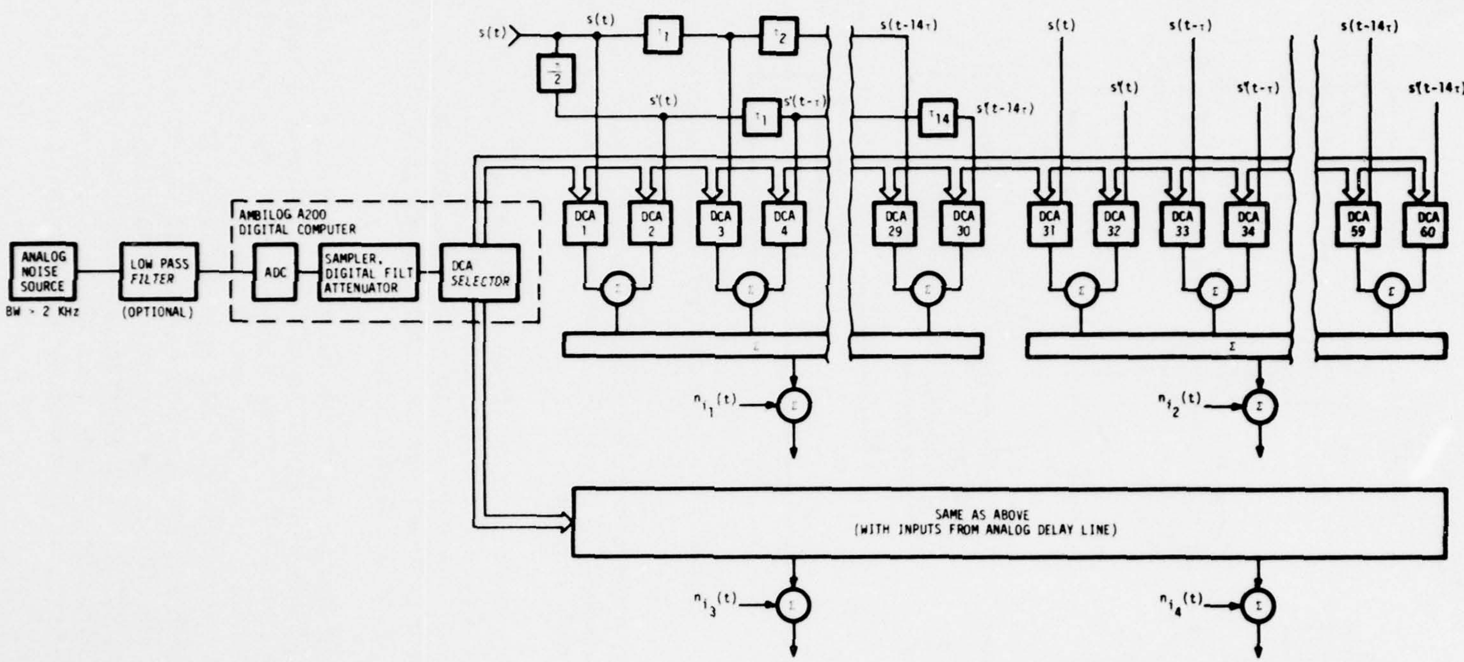


Figure 50. Troposcatter Channel Model Implementation

The digital filter module has been implemented on the hybrid computer system's digital computer. This computer provides the resources to generate 120 uncorrelated random noise sequences, to filter them, and to transfer the resulting signals to the multiplier-summer module. The 120 random noise sequences are generated by sampling a wideband analog Gaussian noise source with an analog-to-digital converter. Capability exists to provide correlation between adjacent random noise sequences by decreasing the bandwidth of the sampled Gaussian noise source. The digital filters are each second order Butterworth types with a nominal cutoff frequency equal to the fade rate and a maximum sample frequency of 40 samples per second. The cutoff frequency can be selected by the user at DCEC. The 120 Gaussian noise output signals from the digital filter are multiplied by the attenuation coefficient, Q (i,W), at that tap and then input to the digitally controlled attenuators in the multiplier-summer module.

The multiplier-summer module consists of four channels, each of which contains 12 pairs of digitally controlled attenuators (one pair per delay line tap) and a summing amplifier. One attenuator in each pair multiplies the signal from one of the taps in delay line 1 by one of the Gaussian functions, $G_i(t)$, while the other attenuator multiplies the signal from the corresponding tap of delay line 2 (which is delayed an additional $\pi/2$ radians) by another Gaussian function, $G_j(t)$. The output of the 12 attenuator pairs is then summed by an analog summing amplifier network to provide the final channel output.

The user specified variables for the troposcatter channel simulation are rms fade rate (0.0001 to 1 Hz) and path parameters (length, antenna size, elevation angles, and effective radius). User interaction with setting up the path profiles, fade rates, and profile displays are discussed in section 2.5.

2.2.2 Line-of-Sight Rayleigh Fading

A line-of-sight Rayleigh flat fading channel can be configured easily from the simulated troposcatter simulation. By setting the coefficients of the first tap pair in each channel to one and turning all other taps off, four Rayleigh flat fading channels can be obtained. Parameters set by the user in this mode include the fade rate and diversity selection.

2.2.3 Channel Test and Validation

Testing and validation of the troposcatter and Rayleigh channel simulations is being performed by measuring the characteristics of each pair of taps. Each pair of taps (in-phase and quadrature) should have a Rayleigh distribution which can be measured by counting the percentage time the median signal level is above a range of signal levels. For the test documented in Table 7, this range was +8 dB to -20 dB in 4 dB increments. For the first tap all channels simulated follow the Rayleigh distribution.

TABLE 7. CHANNEL MEASUREMENTS, FIRST TAP, RAYLEIGH FADING

Signal Level Above Median (db)	Time Level Exceeded (percent)
Channel No. 1	
+8	1.44
+4	19.7
0	49.5
-4	75.7
-8	90.7
-12	96.7
-16	99.0
-20	99.9
Channel No. 2	
+8	1.69
+4	20.1
0	52.2
-4	76.7
-8	90.4
-12	98.9
-16	99.7
-20	99.98
Channel No. 3	
+8	1.52
+4	19.97
0	51.4
-4	76.5
-8	91.0
-12	96.8
-16	99.3
-20	99.97
Channel No. 4	
+8	1.19
+4	18.5
0	48.0
-4	73.2
-8	88.0
-12	94.9
-16	97.6
-20	99.0
	99.5

2.3 Digital Line of Sight Modem Simulation

A Quadrature Partial Response (QPR) line-of-sight (LOS) digital transmission technique has been modeled and programmed on the hybrid computer. Figure 51 is the implemented model functional flow diagram.

This dual diversity technique uses a 3-level partial response filter in each of the symbol data streams that drive the in-phase and quadrature balanced mixers. These mixers are summed to generate a QPR modulated signal that has eight discrete states. On the receive side of the modem the demodulator uses a complementing partial response filter in the I and Q baseband signal paths to recover the I and Q 3-level transmitted baseband signals. This combination of transmit and receive partial response filters produces a raised cosine response.

The demodulation technique is a modified Costas loop that can be used for either QPR or QPSK transmission. It includes a data estimation technique to phaselock a reference carrier to the received signal for coherent detection. Flexibility is provided in the simulation design to allow configuration change, parameter change, and either QPR or QPSK modulation and demodulation. This system is currently being checked out and validated.

2.3.1 Data Input Simulation

The data input module includes several elements modeled and simulated for the DAR. These elements include data generator, serial-to-parallel converter, and differential encoder. Modeling and simulation of these elements are covered in section 2.1, Digital Troposcatter Modem Simulation.

The only change in the data input module for QPR is the substitution of a 20-bit scrambler instead of the 2-bit scrambler of the DAR. A model of this scrambler is shown in Figure 52. For this model data are generated by sampling a Gaussian noise source with the transmitter clock. Scrambling is obtained by modulo 2 summing these data with the result of the modulo 2 sum of the 17th and 20th bits of the 20-stage shift register. This scrambler output also drives the 20-stage shift register. Control logic is provided that allows the simulation user to select either scrambled or unscrambled data. These scrambled or unscrambled data are input to the parallel-to-serial converter which drives the differential encoder. All these data input circuits are programmed using parallel logic on the analog computer.

2.3.2 QPR and QPSK Modulator

At the modulator two paths are simulated for the encoded digital baseband data, as shown in Figure 53. These two paths permit the simulation user to select at the balanced mixers either QPR or QPSK transmission. The QPR baseband signals are derived by using 3-level partial response filter outputs to drive the in-phase and quadrature balanced mixers. These mixer outputs are summed to produce a QPR signal.

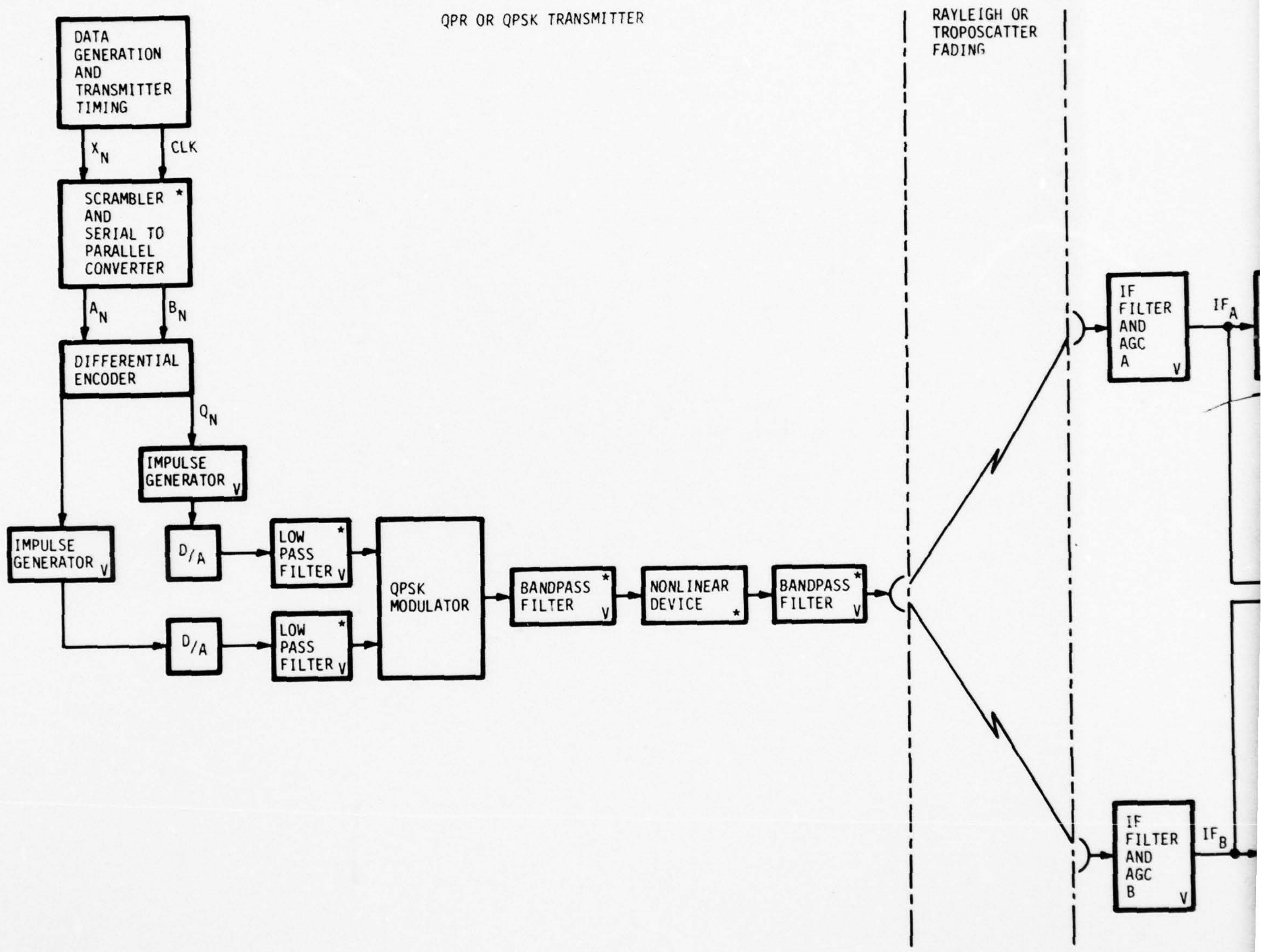
The other input to the balanced mixers is an amplitude and frequency stabilized oscillator programmed on the analog computer. The I and Q 3-level responses are generated by using the encoded I and Q nonreturn to zero (NRZ) logic to drive impulse generators which are input to the Class I partial response filters. Responses of these filters produce a 3-level analog baseband signal which is input to the balanced mixers. The transmit partial response filters are programmed from the following transfer function, using techniques previously described for filter simulation on the analog computer.

$$H_T(S) = \frac{3.25104}{S^4 + 4.3966S^3 + 9.2883S^2 + 8.1050S + 3.25104}$$

The balanced mixers are programmed using analog computer multipliers.

To allow for QPSK transmission, a path is provided directly from the encoded I and Q NRZ data to the modulation select logic. Selection of the desired control signal gates either QPR and QPSK baseband signals to the in-phase and quadrature balanced modulators.

Following the modulator simulation, two spectrum control filters and a nonlinear device were modeled and programmed identically to those in the DAR simulation (section 2.1.2) and remain configuration options for the simulation user.



QPR OR QPSK TRANSMITTER
RAYLEIGH OR TROPOSCATTER FADING
DATA GENERATION AND TRANSMITTER TIMING
X N
CLK
SCRAMBLER AND SERIAL TO PARALLEL CONVERTER *
A N
B N
DIFFERENTIAL ENCODER
Q N
IMPULSE GENERATOR V
IMPULSE GENERATOR V
D/A
D/A
LOW PASS FILTER V *
LOW PASS FILTER V *
QPSK MODULATOR
BANDPASS FILTER V *
NONLINEAR DEVICE *
BANDPASS FILTER V *
IF FILTER AND AGC A V
IF A
IF FILTER AND AGC B V
IF B

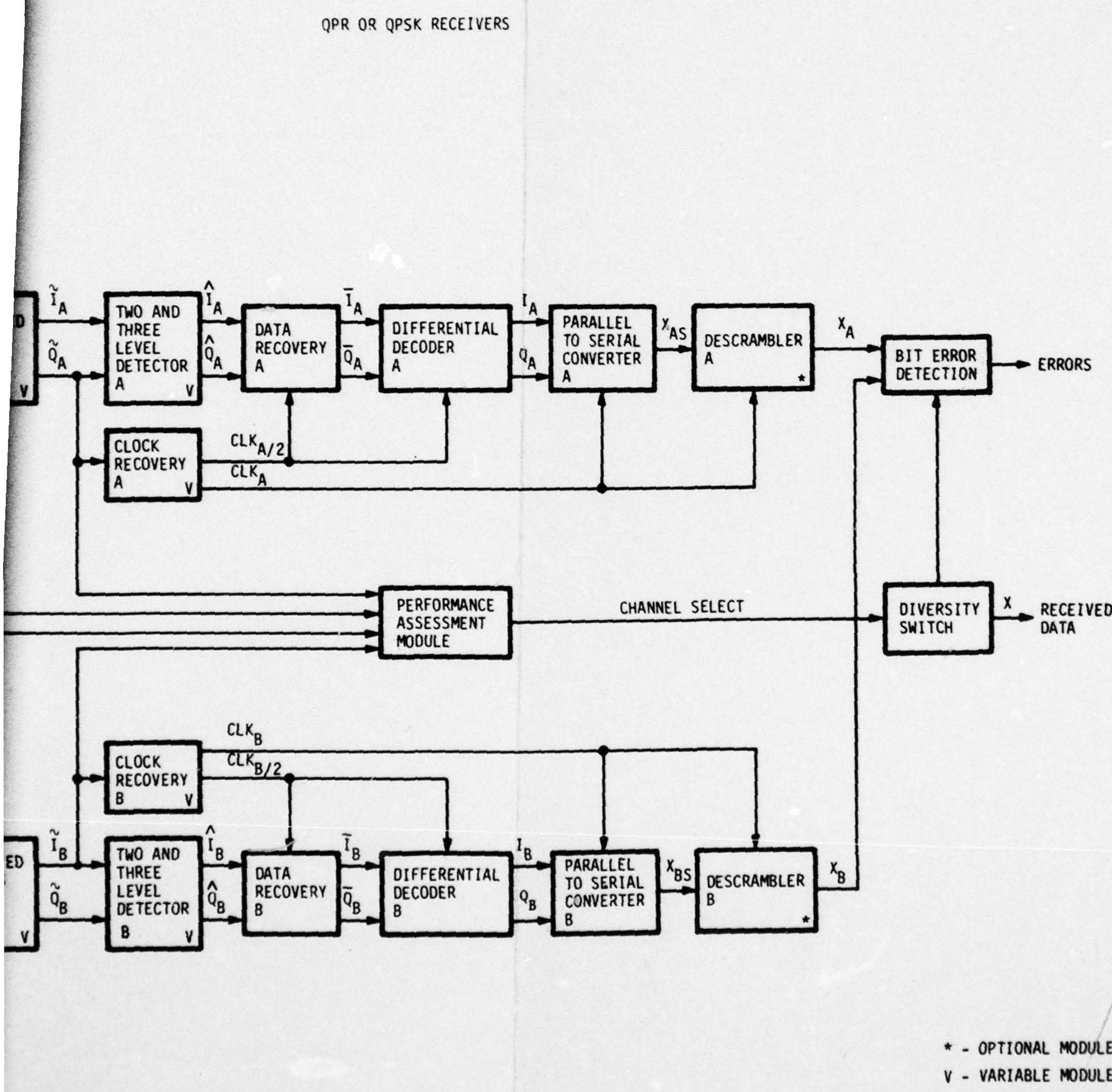


Figure 51. QPR and QPSK Dual Diversity Simulation

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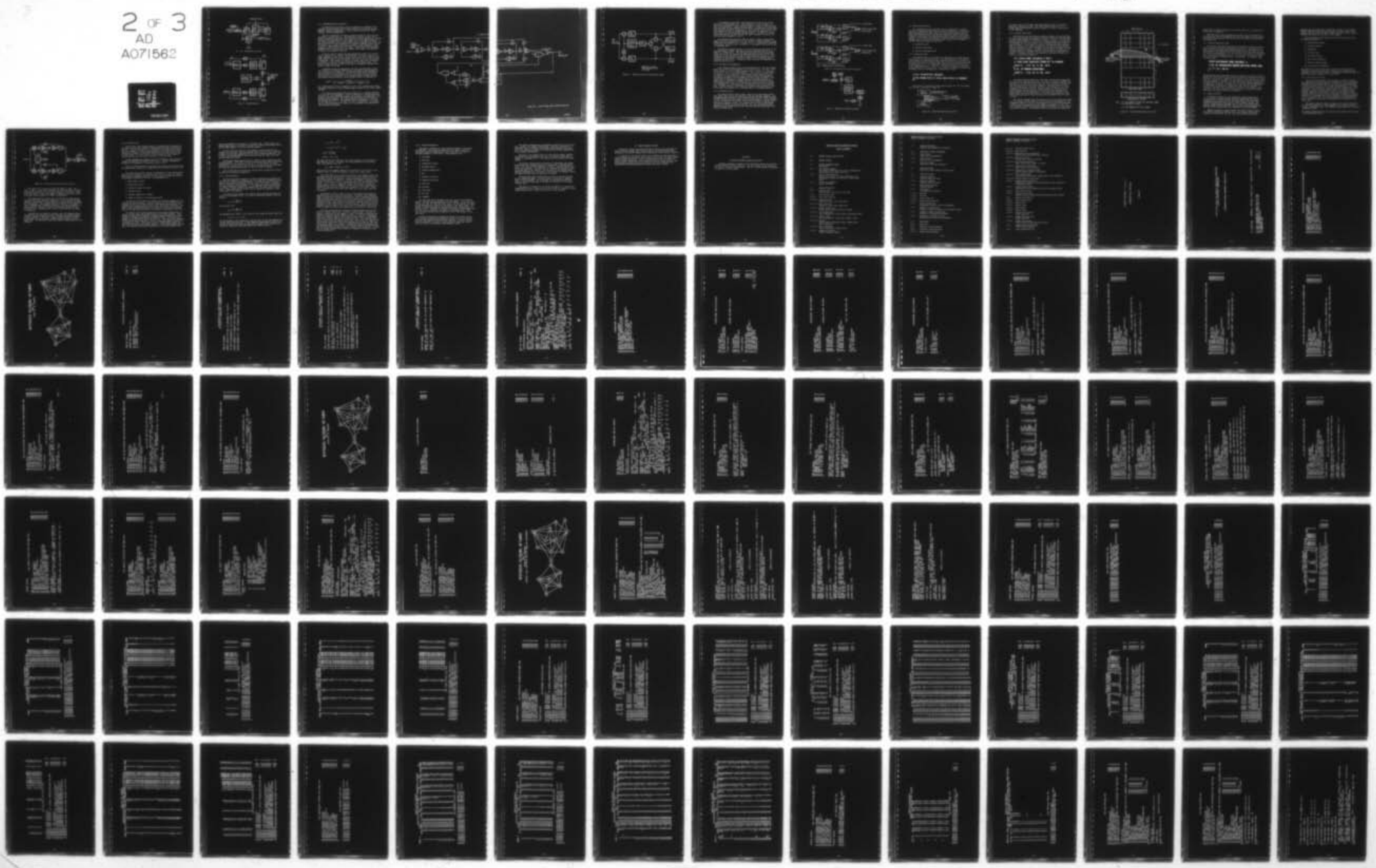

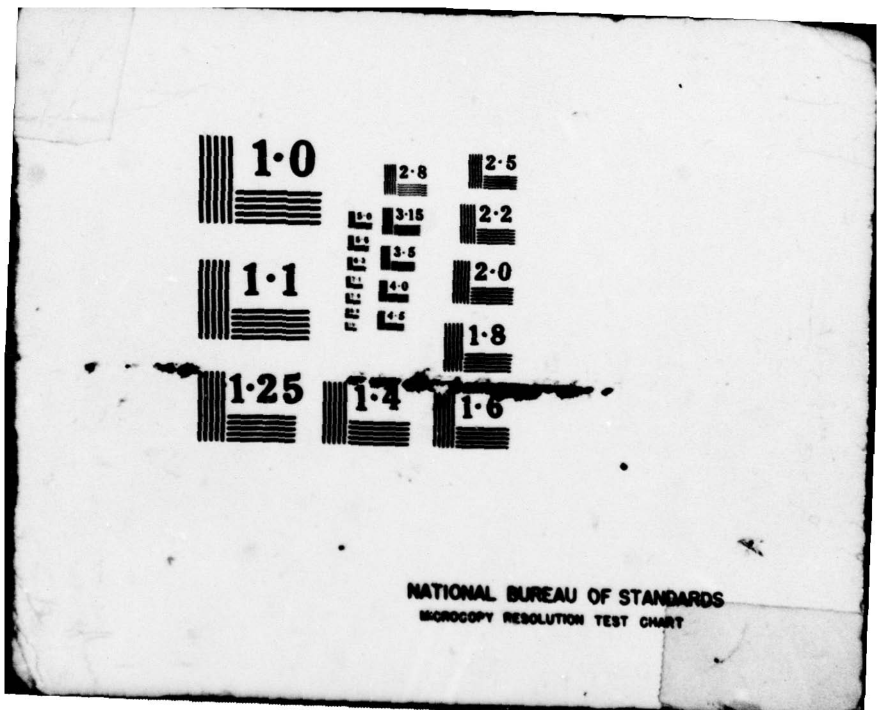
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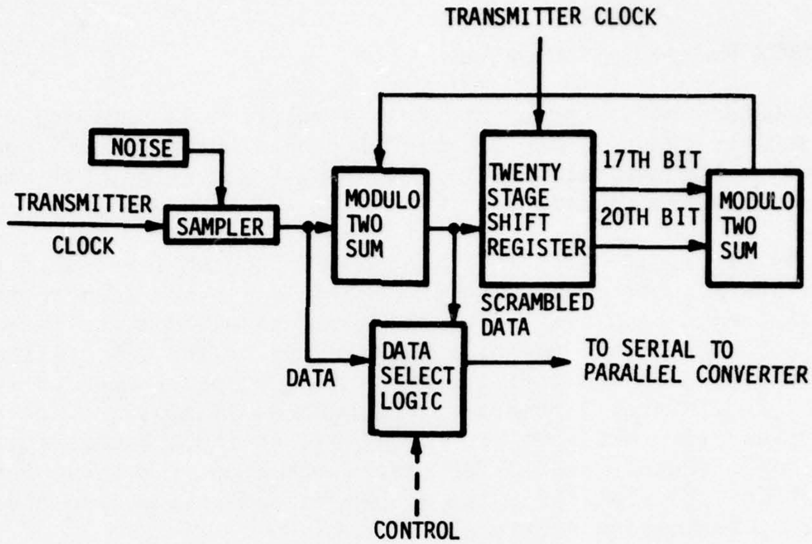


Figure 52. QPR/QPSK Data Input Model

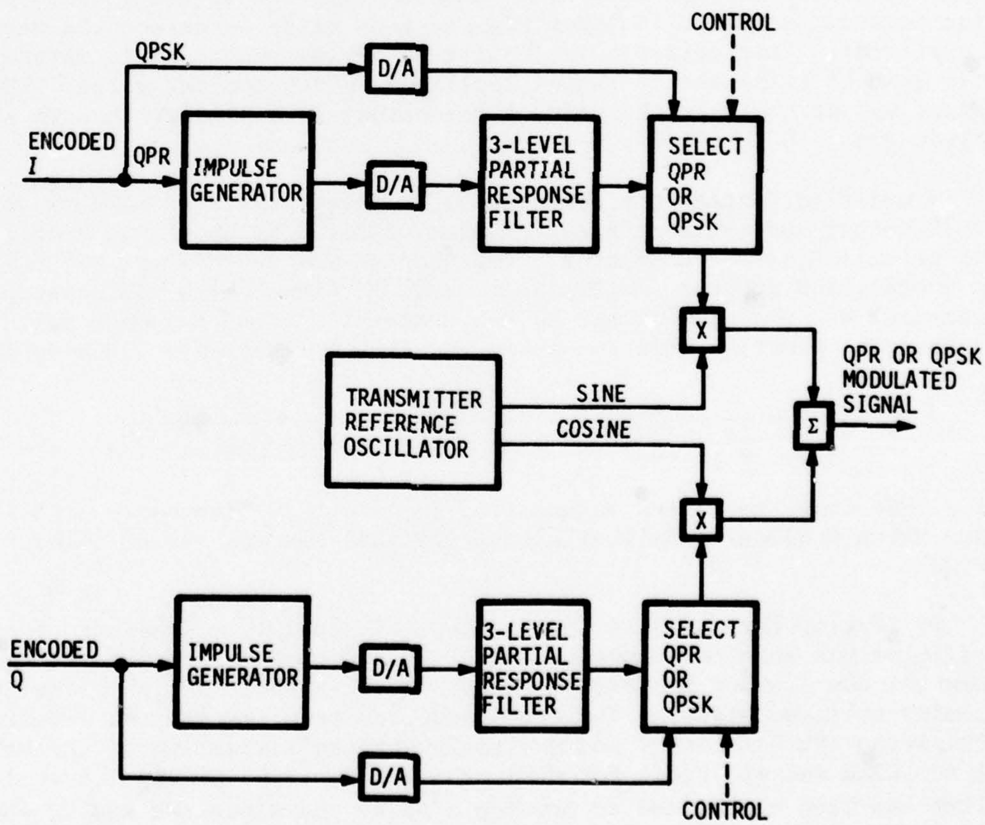


Figure 53. QPR/QPSK Modulator

2.3.3 QPR/QPSK Receiver Simulation

The QPR/QPSK dual diversity receiver simulation is composed of two identical receiver chains, each of which includes an IF and AGC section, modified Costas loop demodulator, 2- and 3-level detection, bit timing recovery, and data regeneration.

Figure 54 illustrates the analog computer program for one of the two identical IF and AGC sections. The simulated IF section accepts the received transmitted signal plus noise where the received signal may be fading, and selects a chosen signal-to-noise (SNR) ratio as the SNR coefficient. The filter simulated on the analog computer can be programmed to reflect the characteristics of either Butterworth or Chebychev bandpass filters with up to 8 poles. User programs have been developed to input bandwidth, center frequency, ripple factor, and filter order. Programs for these functions, together with the calculation of the stagger tuned stages, are addressed in section 2.5, Supportive Software.

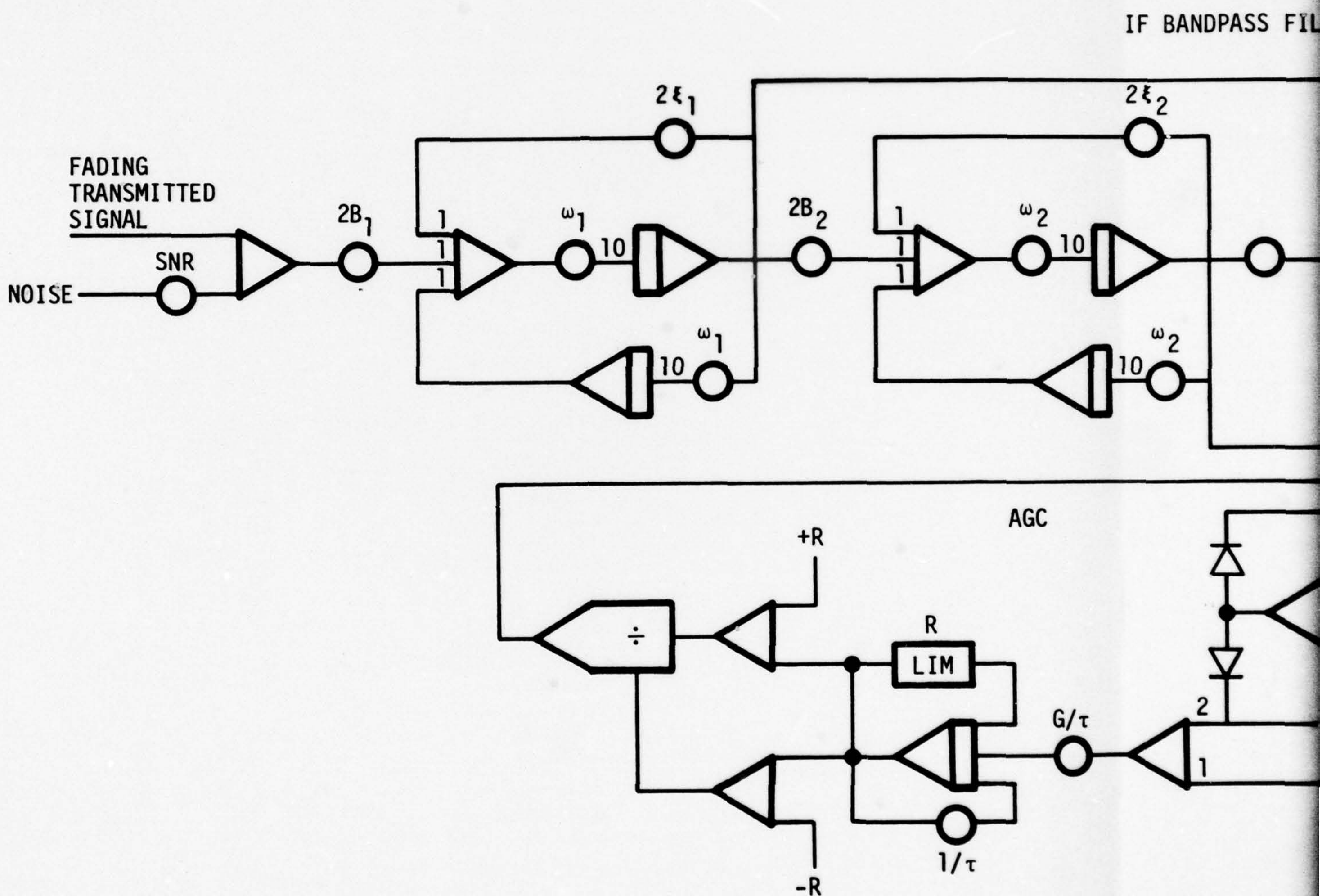
An AGC for each IF section has been mechanized using a full wave rectifier, lowpass filter, divider, and multiplier. The signal from the IF output amplifier is full wave rectified and filtered with a lowpass filter (time constant equal to 10 times highest fade rate) to detect the received IF amplitude. This variable is input to a divider whose ratio determines an IF gain to raise the IF signal amplitude to its nominal value. The divider output controls the gain of the output IF amplifier through a multiplier (range 0 to 60 dB).

A modified Costas loop demodulator has been simulated which accepts the IF output and coherently demodulates either QPSK or QPR depending on user selection at the modulator. For QPR the lowpass filters following the correlation process (multiplication of IF signal with the coherent reference) are the complements to the transmit partial response filters. The transfer function used for these receiver filters in a QPR mode is

$$H_R(S) = \frac{17.149}{S^4 + 16.895S^3 + 33.5581S^2 + 35.8009S + 17.149}$$

For a QPSK mode the filter is modified to give a full response with linear phase which produces a 2-level baseband signal instead of the 3-level signal for QPR.

To develop the modified Costas loop (Figure 55), a coherent reference oscillator has been programmed. Using the filtered dc cross-coupling component of the I and Q baseband signals, the reference is phaselocked to the incoming received signal. The cross-coupling products are the result of multiplying the baseband I and Q signals with an estimation of the value (±1 for QPSK and +1, 0, -1 for QPR) of Q and I, respectively. A lead/lag filter has been mechanized to develop a $\Delta\omega$ to phaselock the analog amplitude stabilized oscillator.



IF BANDPASS FIL
FADING
TRANSMITTED
SIGNAL
NOISE
SNR
2B1
2ξ1
ω1
10
2B2
2ξ2
ω2
AGC
+R
-R
R
LIM
G/τ
1/τ

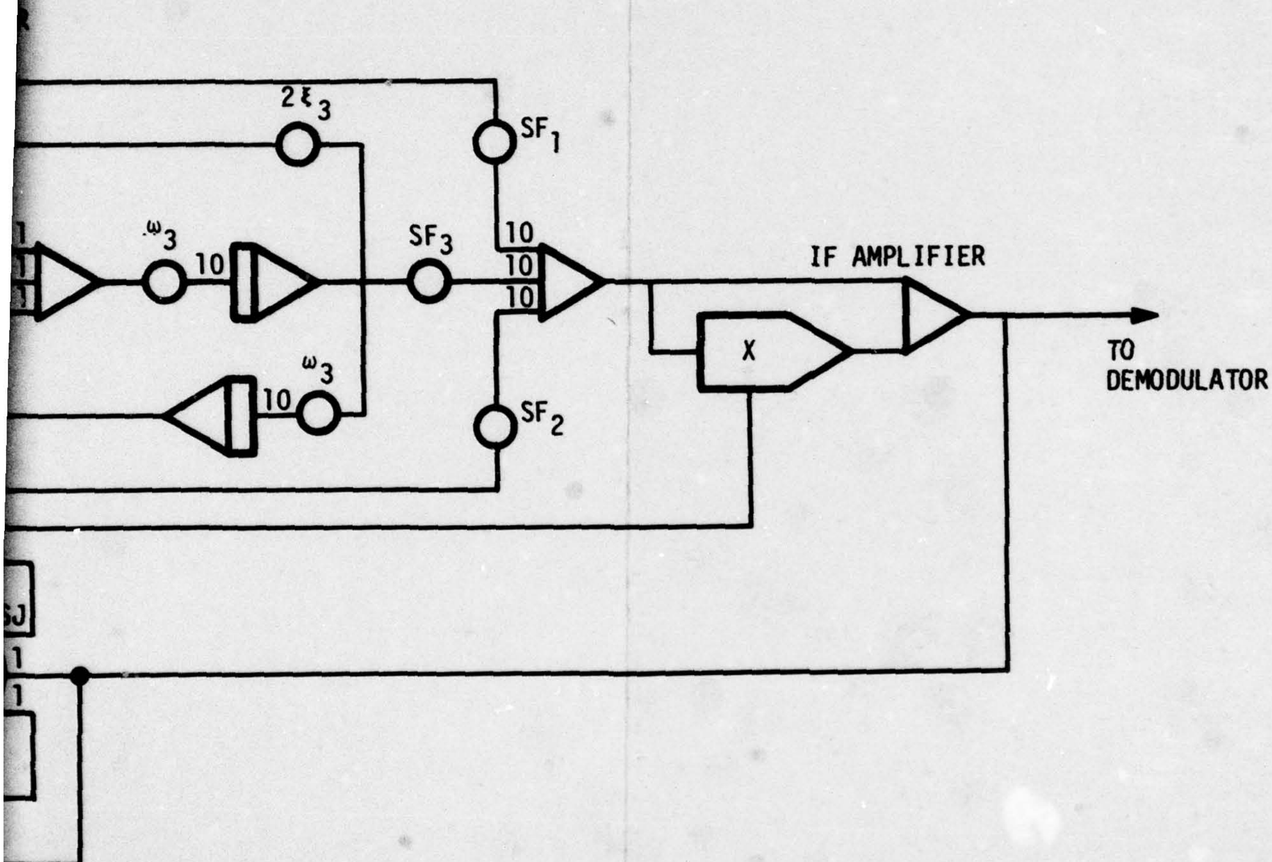
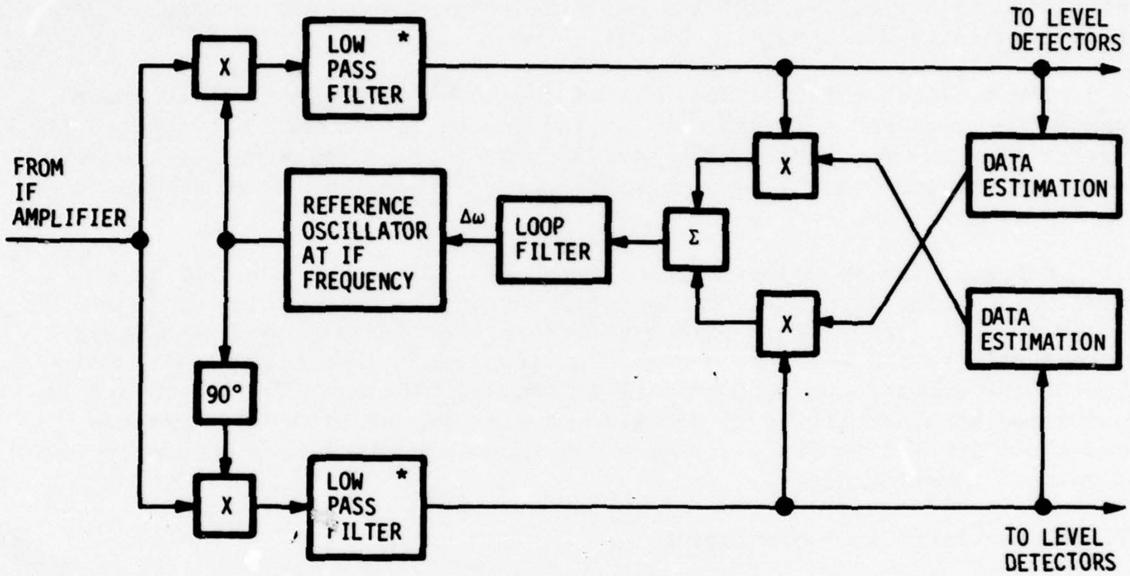


Figure 54. Line-of-Sight Modem IF/AGC Simulation

2



*COMPLEMENT OF TRANSMIT PARTIAL RESPONSE FILTER IN QPR MODE

Figure 55. Modified Costas Loop Demodulator Model

To accommodate either QPSK or QPR requires both 2-level and 3-level detection of the baseband data. This simulation is shown in Figure 56. Each of the demodulated I and Q baseband signals is input to plus and minus level detectors which, combined with threshold or slicing level coefficients, form the upper and lower slicing levels. These slicing levels and the baseband signals are input to comparators for detecting the presence of +1, 0, and -1 data from the demodulated baseband signals. For QPSK, the slicing coefficients are set to zero and only the upper comparator is used to detect the binary baseband +1, and -1.

The detected three levels for QPR are input to logic circuits which sample the received baseband data at the instant of maximum response, using timing from the receiver clock. For QPR, a +1 or -1 represents a recovered zero and zero represents one. For QPSK, a +1 represents a recovered one and -1 represents zero.

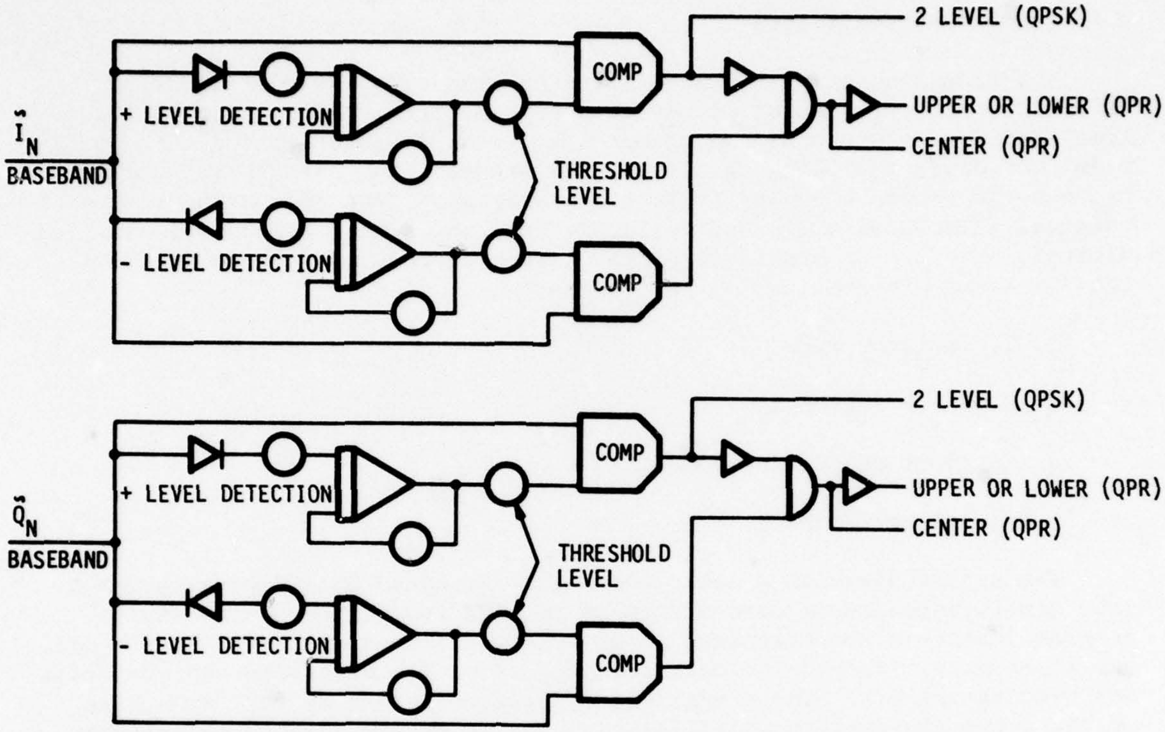
Differential decoding follows in the level detection simulation if the modulated signal is QPSK. QPR does not require decoding since it is already in a decoded state. This differential decoder has been mechanized identically to the one used for the DAR simulation (section 2.1.3). Following the decoder the detected QPR or decoded QPSK was parallel-to-serial converted and descrambled by using an inverse of the scrambling process described in section 2.3.1. Timing for these functions is provided by the simulated receiver clock.

2.3.4 Receiver Clock Simulation

A bit timing recovery circuit has been simulated for the line-of-sight modem that provides synchronization for the data recovery circuits. This model (Figure 57) uses an analog phaselock loop to phaselock a reference oscillator to one of the baseband signals. The I-channel baseband signal was chosen for this simulation. This baseband analog signal is sliced to produce a ±1 square wave from which a good spectral line amplitude at the baseband frequency can be obtained by using a logical one-shot. The signal from the one-shot is analog-to-digital converted and input to a phase detector (multiplier) together with the clock reference oscillator. The resulting phase error is filtered using a lead/lag circuit to obtain a dc component, $\Delta\omega$, which phaselocks the reference clock to the received data. A phase shifter is included at the output of the oscillator to correctly phase the sampling of the baseband data at its maximum response.

2.3.5 Diversity Switch

The diversity switch model accepts inputs from a performance assessment module that affects the selection of the two diversity channels. This assessment module includes an eye-opening detector and AGC control voltage. For the diversity switch to switch in an errorless manner, a clock averaging circuit is included in the model. This circuit develops an average clock from the two receiver clocks. The average clock is used to time channel selection and effect an errorless switch. Bit error circuits have been modeled for each channel and for the diversity selected channel which also uses the average clock.



NOTE: THRESHOLD LEVEL IS ZERO FOR QPSK

Figure 56. Two and Three Level Detection Simulation

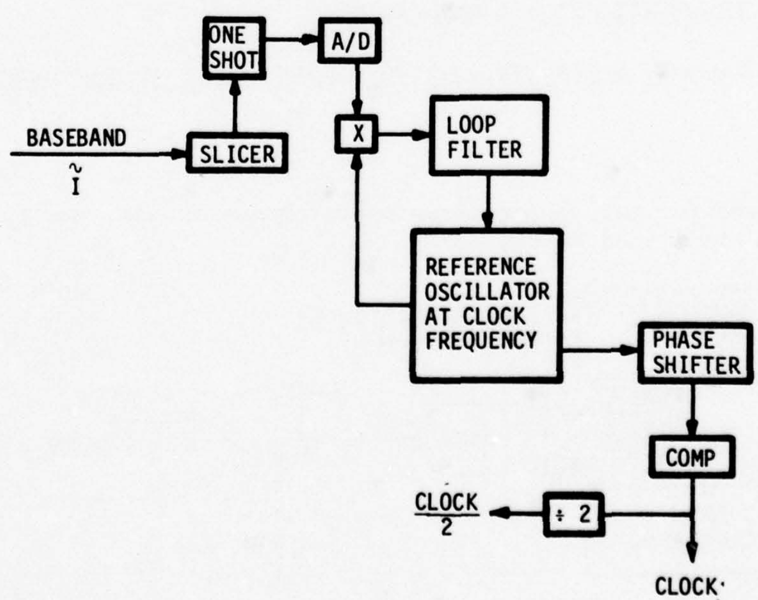


Figure 57. QPR/QPSK Bit Timing Recovery Model

2.4 Frame Synchronization

The transmission system simulation has the capability of studying effects on synchronization of the data stream transmitted as a structured Time Division Multiplex (TDM) frame. The frame synchronization effects model was developed using an all-digital program that permits interaction between the remote user and frame synchronization program via the remote terminal. The program is appropriately interfaced with the analog-parallel digital logic of the hybrid computing system to model the three modes of the TDM frame synchronization, which are:

1 Transmitter mode

2 Receiver search mode

3 Receiver maintenance mode.

2.4.1 Transmitter Mode

The synchronization effects model was simulated by a digital program that controls the input data stream of the TDM transmitter. The digital program inserts a predetermined frame synchronization bit every F bits into the input data stream. The data frame contains F-1 data bits and one frame synchronization bit. The predetermined pattern formed by the frame bits is the repeating pattern ...1111111... The frame bit density is selected by the remote user as shown below. The program is capable of accepting any meaningful ratio of the frame rate to the total bit rate.

```
ENTER TRANSMITTER VARIABLE

ENTER FRAME RATE TO TOTAL RATE RATIO IN PERCENT
10
```

The circuit for gating the frame synchronization bit into the random data stream is indicated in Figure 58.

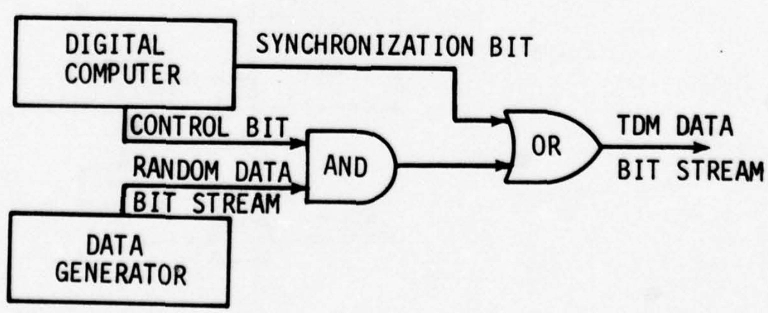


Figure 58. Frame Synchronization Interface

The control bit is "0" during frame synchronization and "1" otherwise, gating the random data stream. The frame synchronization bit is a "1" during frame synchronization, giving a repeated ...111111... pattern and is "0" otherwise.

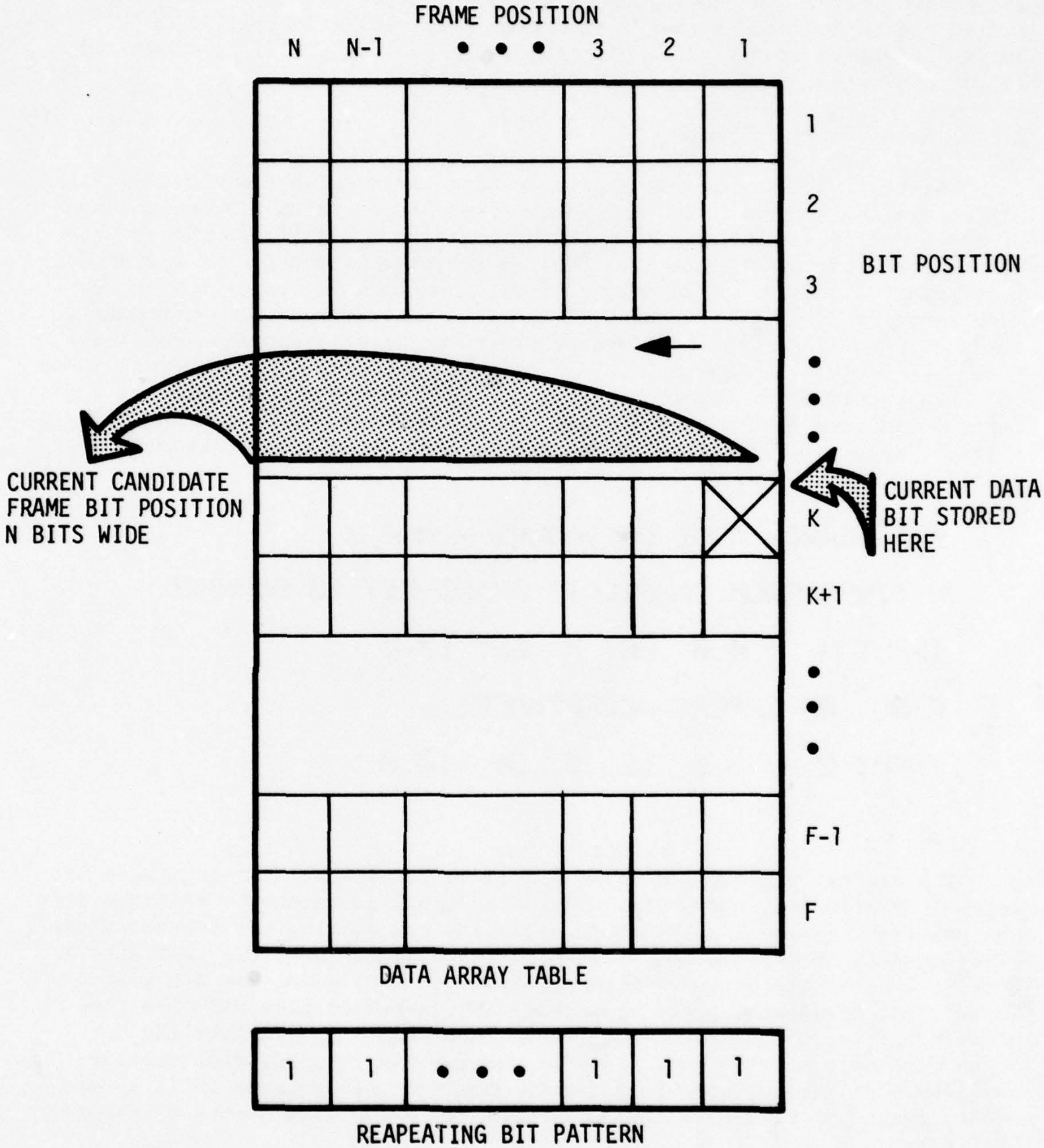
2.4.2 Receiver Search Mode

The receiver search mode digital subprogram samples the received data bit stream and searches each candidate frame bit position a specified number of times tested against the repeated bit pattern ...111111... If the candidate frame bit position is in error an acceptable amount, the search mode is terminated and the total number of bits accumulated during the search mode is printed. If the number of errors is unacceptable, then candidate frame bit positions are tested sequentially until an acceptable candidate frame bit position is found. The remote user specifies the number of times (N) each candidate frame bit is scanned, and the number of errors (E) acceptable between the candidate frame bit position and the repeating test pattern. An example follows of the remote user interactive terminal requests for search mode parameters.

```
SET SEARCH MODE VARIABLES N AND E

N TIMES EACH CANDIDATE FRAME BIT IS SCANNED

INPUT N... 4.0 .LE. N .GE. 10.0
8.
E NO. OF ERRORS ACCEPTABLE

INPUT E... 0.0 .LE. E .GE. 10.0
1.
```

The digital program generates a data table, illustrated in Figure 59, which is F bits long and N bits wide. The table is formed by shifting left one position the previously stored data bits and storing the presently sampled data bit in the vacated first position. Since the table is F bits long, the same data bit positions relative to the framing bit are stored in adjacent horizontal positions. When N-1 frames of data bits are completely stored, the next receiver clock interrupt will complete the N scans necessary for the comparison of the first current candidate frame position with the appropriate pattern. The search continues until a candidate frame position is found that meets the acceptable number of errors criteria.

The current candidate frame bit position will be exclusively OR'ed with the test pattern and the number of bits in error will be accumulated. The accumulated number of errors is then compared with the specified acceptance criteria, and if acceptable the search mode is terminated. If not, the next candidate frame bit position is updated and tested on the next receiver clock pulse interrupt. The candidate frame bit positions are updated and



NOTE: N IS THE NUMBER OF TIMES EACH CANDIDATE FRAME BIT POSITION IS TESTED.

F IS THE NUMBER OF BITS IN A FRAME.

Figure 59. Frame Synchronization Data Table

tested until a frame bit position is found that meets the criteria and the search mode is terminated.

When the search mode is terminated the remote user is informed that the search mode has been terminated, and the total number of bits (receiver clock pulse interrupts that have occurred since entering the search mode) are printed out.

2.4.3 Receiver Maintenance Mode

The receiver maintenance mode digital subprogram is remote-user interactive, accepting as input the maximum count A used to initialize an up-down counter at the beginning of the maintenance mode. Each time an error exists between the expected frame sync bit and the received frame sync bit the counter is decremented or, if the bits agree, the counter is incremented up to the specified maximum count, A. If the counter is depleted, frame sync is lost and the maintenance mode is terminated. The terminal inputs are shown below.

```
ENTER MAINTENANCE MODE VARIABLE, A

A NO. OF ACCUMULATED ERRORS DEFINING FRAME LOSS

A = 7.,15., OR 31.
7.
```

The maintenance mode subprogram continues to maintain the data array table (Figure 59) except that the frame sync bit position is situated at the top of the table. The table is updated by the receiver clock queue and the current data bit inserted in the table. At the appropriate time the frame sync bit is tested against its expected state and the up-down counter incremented or decremented as necessary. If frame sync is lost and the maintenance mode is terminated, an appropriate message that identifies the new mode is printed to the remote user, followed by a printout of the number of bits (receiver clock pulse interrupts) accumulated since entering the maintenance mode. The search mode is then reentered.

2.5 Support Software

The support software for the transmission system simulation includes the set of digital programs and their subprograms that allow the remote user to interface with the Martin Marietta hybrid computer transmission simulation system via the remote terminal at DCEC. The support software permits the remote user to alter the system configuration, change system parameters, test and verify system elements, and make analytical evaluations of the transmission system performance.

Because the support software outgrew the digital computer system, the computer program was broken up into a main program that remains resident in lower memory, and into other functionally grouped sub-

programs that are loaded into a common area of memory, by overlaying whatever subprogram was previously resident into that region. This approach allows a relatively small digital computer to perform digital programs that exceed the core size of the computer.

The main program, when executed, lists for the remote user the following broad options:

1 Power spectral density

2 Frequency response

3 Eye pattern

4 Bit error test

5 Plot delay profile

6 Alter filter parameters

7 Return to nominal system

8 Alter system or parameters.

The remote user is then instructed to select one of these options, whereupon the computer overlays the selected option program and its subprograms into a region of memory. Examples of outputs from these programs are included in Appendix G of this report.

2.5.1 Power Spectral Density

The power spectral density (PSD) program is a hybrid technique that incorporates an analog PSD circuit (Figure 60) that is controlled and sampled by the digital computer. The analog circuit generates by a Fourier technique the PSD of the signal being analyzed. The signal to be analyzed is multiplied by the sine and cosine outputs of a local oscillator. These signals are then filtered by a lowpass filter to eliminate all but the constant terms A and B, the in-phase and out-of-phase components of the signal. These two resultants are then squared, added, and lowpass filtered (averaged) to produce a term proportional to the average power of the signal at a frequency specified by the local oscillator. This signal is sampled by the digital computer, converted to decibels, and normalized to be plotted for the remote user.

The support software allows the remote user to select and obtain the spectral occupancy of a signal measured at 1) modulator output, 2) first transmitter filter, 3) transmitter nonlinearity, and 4) second transmitter filter.

The digital program switches the selected output signal into the input of the analog PSD circuit.

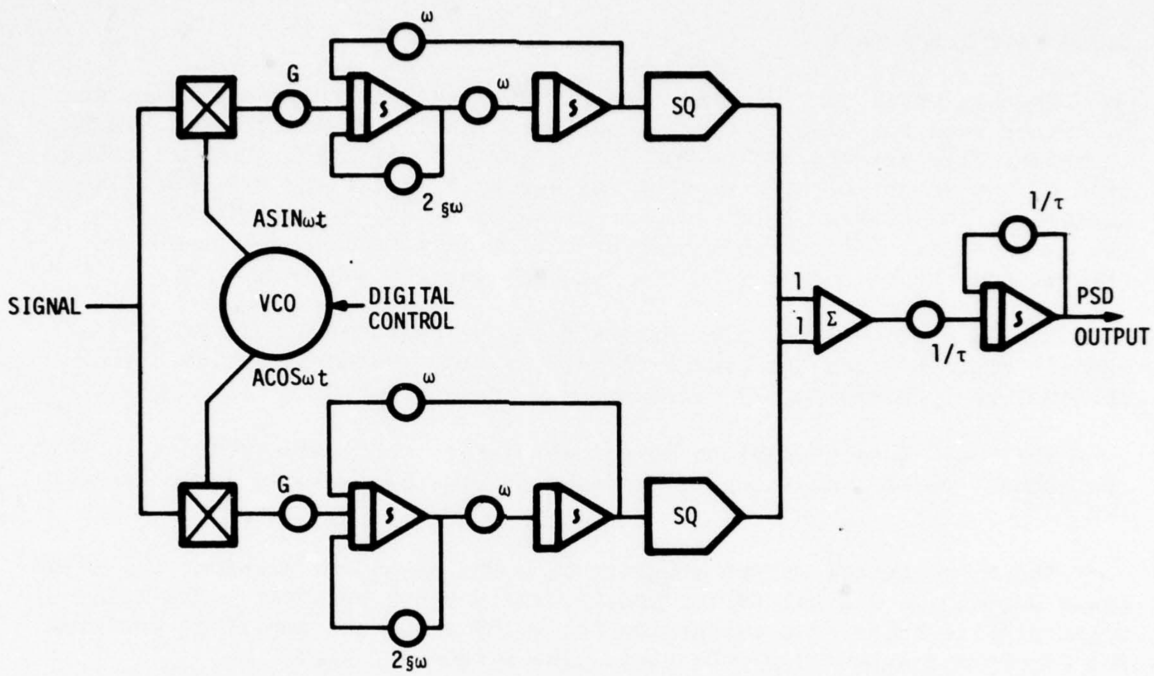


Figure 60. Power Spectral Density Analog Circuit

The remote user is queued to enter the number of lags - up to 2000. A lag is a term used to describe the process by which the power contained in a signal at a particular frequency is determined. Therefore, the number of lags is the number of samples of the power output by the PSD circuit excited at a number of frequencies.

The program asks the remote user to enter the low frequency and then enter the high frequency in megahertz. These frequency extremes determine the spectrum of frequencies over which the spectral occupancy will be measured. The frequency spectrum is divided by the number of lags to determine the incremental frequency. The power is sampled for each incremental frequency, converted to decibels, normalized, and plotted out as a continuous plot of power in decibels over the range of frequencies.

In addition to the spectral occupancy plot, the program displays the upper and lower frequency bounds of the band of frequencies which contain 99 percent of the power. This 99 percent spectral occupancy is determined for the frequency extremes defined previously by the remote user. The frequency at which the center of power exists is also displayed.

2.5.2 Bit Error Test

The bit error test program consists of a program that calculates the bit error rate for various system configurations which may be selected by the user. The bit error rate for a configuration is simply the accumulation of the number of errors occurring during a specified period of time divided by the number of interrupts generated by the symbol clock during the same period. The total number of bits transmitted, total number of errors, and the bit error rate are printed out for each test.

System configuration elements that may be changed in this program are channel configuration and signal-to-noise ratio. Channel configuration options are 1) Rayleigh, 2) troposcatter, and 3) "out."

The "out" option consists of switching the analog simulation such that the channel model simulation is bypassed and the AGC gain is forced to zero.

The troposcatter option consists of subprograms to calculate the delay power profile, a digital filter module, and a bit error test. The delay power profile subprogram calculates the delay power and amplitude profiles for parameters selected by the user. The parameters are:

1 Path length in miles

2 Smooth earth option

3 Horizontal angles in degrees

4 Effective earth

5 Antennae beamwidths in degrees

6 Number of points at 50 nanosecond spacing.

If the smooth earth option is selected, the horizontal angles are not required for the calculation. While the program has the capability of calculating 50 points on the delay profile, only twelve will be used by the digital filter program because there are only twelve delay line taps. The delay, power, and amplitude values are output as a table, and an optional plot of the power profile relative to the delay is displayed for the user.

The digital filter module generates 96 uncorrelated random noise sequences, filters them, and transfers them to the analog computer. These signals are generated by sampling a wideband analog Gaussian noise source filtered by a second order digital Butterworth filter. The filter has a nominal cutoff frequency equal to the fade rate. The fade rate is selected by the user and has a fade rate of 1 Hz at the maximum sample frequency of 40 samples per second. Slower fade rates are accomplished by using the same filter but varying the sample frequency. These fading signals are output to the digitally controlled attenuators on the analog computer where

they are multiplied by the outputs of the delay taps. These products are summed appropriately to provide the troposcatter channel model signals which are the input signals to the four receiver channels.

The bit error test portion of the program is synchronized with the digital filter program. Since the digital filter values are zero initially, a number of errors are generated until realistic values are generated. The bit error test program ignores these errors and does not begin its accumulation during this period.

The Rayleigh fading channel option is similar to the troposcatter channel mechanization. The first term of the delay amplitude profile attenuation coefficients is 1 and the other eleven are 0. On the analog, the terms multiplied by the first delay line tap and its quadrature are the only terms that form the fading channel inputs to the four receiver channels.

Both the Rayleigh and troposcatter channel models automatically switch the AGC into the system configuration.

2.5.3 Filter Alteration

The filter alteration program is a hybrid technique that provides the user with the capability of changing the two transmitter RF bandpass filters and the four receiver IF bandpass filters. The user may select a Butterworth or Chebychev characteristic and the order of the filter, and specify its center frequency and bandwidth. If the Chebychev filter characteristic is selected, the user supplies the computer with the ripple factor in decibels. These parameters are entered into the system as responses to questions asked by the computer.

The approach taken computes the lowpass filter prototype and then converts it to a bandpass filter. The roots of Butterworth lowpass filter are given by

$$\sigma_K = \sin \left(\frac{2K-1}{N}\right) \cdot \frac{\pi}{2}$$

the real part, and

$$\omega_K = \cos \left(\frac{2K-1}{N}\right) \cdot \frac{\pi}{2}$$

the imaginary part, where n is the order of the lowpass prototype filter and

$$K = 0,\ 1,\ 2,\ \ldots,\ 2n.$$

For the purposes of this simulation, only the roots in the upper quadrant of the left hand plane are used. If the Chebychev characteristic option is selected, the roots derived for the Butterworth lowpass filter prototype are altered by applying an algorithm based on the ripple factor, S.

$$\varepsilon_p = (10^S - 1)^{-1/2}$$

$$a = [(\varepsilon_p{}^2 + 1)^{1/2} + \varepsilon_p]/n$$

$$\text{tanha} = \frac{a - 1/a}{a + 1/a}$$

$$\text{cosha} = .5(a + 1/a)$$

The cosha term is the normalized 3 dB cutoff frequency for the Chebychev characteristic filter. The tanha term is multiplied by the real term. Thus, the Chebychev roots are

$$r_K = \text{cosha}\ (-\text{tanha}\ \sigma_K + j\omega k).$$

The K roots of the lowpass prototype are converted to the 2K roots of the bandpass filter by using the quadratic equation for complex roots.

The coefficients for the transfer function of the bandpass filter are determined from the derived roots. These coefficients scaled properly are the values to which the digitally controlled attenuators are set in the filter mechanization of Figure 43. However, the frequency response characteristic of the filter will not compare favorably with its theoretical response. This is due to a number of elements but primarily because the analog computer system was designed to meet specification requirements at frequencies less than the 10 kHz scaled frequency of the filter. Therefore, a program was written that would tweak the filters until they were acceptable.

The bandpass filters consist of up to three stagger-tuned stages to approximate the total filter characteristic. Therefore, each individual stage is adjusted by alternately adjusting the center frequency potentiometers until the phase error is less than one degree and then adjusting the feedback bandwidth potentiometer until the gain is within 1 percent of its theoretical value. Each section is alternately adjusted realtive to phase and gain six times before going to the next section. When each section is adjusted, then the output of the total filter is adjusted to unity at the center frequency by varying the forward gain of the output of the filter.

The user has the option of running a frequency response test on the filter to verify visually that the filter is set properly. The user responds to questions from the computer to enter the lowest and highest frequencies of interest and the number of points to be tested. The program works by driving the input of the filter with the output of an amplituded stabilized variable frequency controlled oscillator. The resulting filter output is peak detected, sampled, and stored. This process is repeated for each frequency point until the entire characteristic is stored. The ratio of the filter output to its input is determined in decibels, together with corresponding phase characteristic. The gain and phase characteristics for each frequency point are then printed in tabular form for the user. A Bode plot of the gain characteristic relative to changes in frequency is also displayed graphically.

2.5.4 System Configuration

The support software also lists selected elements of the system configuration. This system configuration list informs the user of the present system configuration and allows the user to change individual parameters of the system. These parameters are:

1 Run number

2 Time gate

3 Transmitter filters

4 Nonlinear device

5 Channel configuration

6 AGC

7 Receiver IF filters

8 Coherent filter gain

9 S/N ratio

10 Diversity

11 Drive power

12 Run time

13 Scrambler.

The time gate option determines the duty cycle of the modulated signal. The time gate mechanization has three modes: on all the time, off all the time, and selectable duty cycle. The user chooses the width of the data burst as a percent of the period of the symbol clock. The method of mechanization has 15 bits resolution with a granularity of 5 percent per bit. Although the computer will accept any percentage value, the duty cycle is rounded to the nearest 5 percentage point. However, any value greater than 75 percent is set to 100 percent or full duty cycle.

As well as discussing altering the receiver IF filters, section 2.5.2 discusses altering the transmitter filters that are both before and after the simulated nonlinear power amplifier. However, the user has the flexibility to select or delete from the signal path either filter as well as the nonlinear power amplifier circuit.

The channel configuration is delineated in section 2.5.2, Bit Error Test. However, the channel configuration - Rayleigh, troposcatter, or nonfading - may be included in the system without running a bit error test. The presence or absence of the AGC may be selected independently of the channel configuration.

The gain of the coherent filter in each receiver channel demodulator module may be specified by the user. The coherent filter gain is limited to a maximum of 0.75. The coherent loop is unstable for larger values.

The receiver channels may be subjected to interference and analog white noise source bandpass filtered to approximate a Gaussian distribution. The user has the flexibility to select a signal-to-noise ratio as an input parameter. The S/N ratio is calibrated to specify the ratio of the rms value of the signal to the rms value of the Gaussian noise measured independently at the output of the receiver IF bandpass filters. The signal-to-noise ratio is specified in decibels.

The drive power gain is selected by the user to specify the power of the transmitted signal. The drive power is specified in decibels where -20 dB is maximum. The noise input is also reduced proportionately to the drive power gain to maintain the integrity of the signal-to-noise ratio.

The amount of diversity in the system configuration to recover the transmitted serial bit stream is at the user's option. Options are none, single channel, dual, or quad for all four receiver channels.

3.0 REMOTE TERMINAL SUPPORT

During this 9-month reporting period Martin Marietta has supported 25 hours of remote terminal time to system control and transmission systems personnel at the Defense Communications Engineering Center, Reston, Virginia.

In addition to the hybrid terminal time, software has been developed to allow an interactive interface with complex system control and digital transmission systems simulations. Using a conversational query and answer response, dynamic simulations can be configured from the remote terminal, and both analog and digital data and displays of resulting responses can be obtained from the Tektronix graphics terminal and chart recorder.

APPENDIX A

INTERACTIVE NETWORK SIMULATION OPTIONS

Appendix A presents a complete set of selectable options for operation of the interactive network simulator. Specific options can be located by the table of contents located herein. The use of these options is addressed in section 1.5 of the report.

NETWORK SIMULATOR INTERACTIVE OPTIONS

TABLE OF CONTENTS

HYBRID NETWORK SIMULATOR

INTERACTIVE OPTIONS

3/30/78

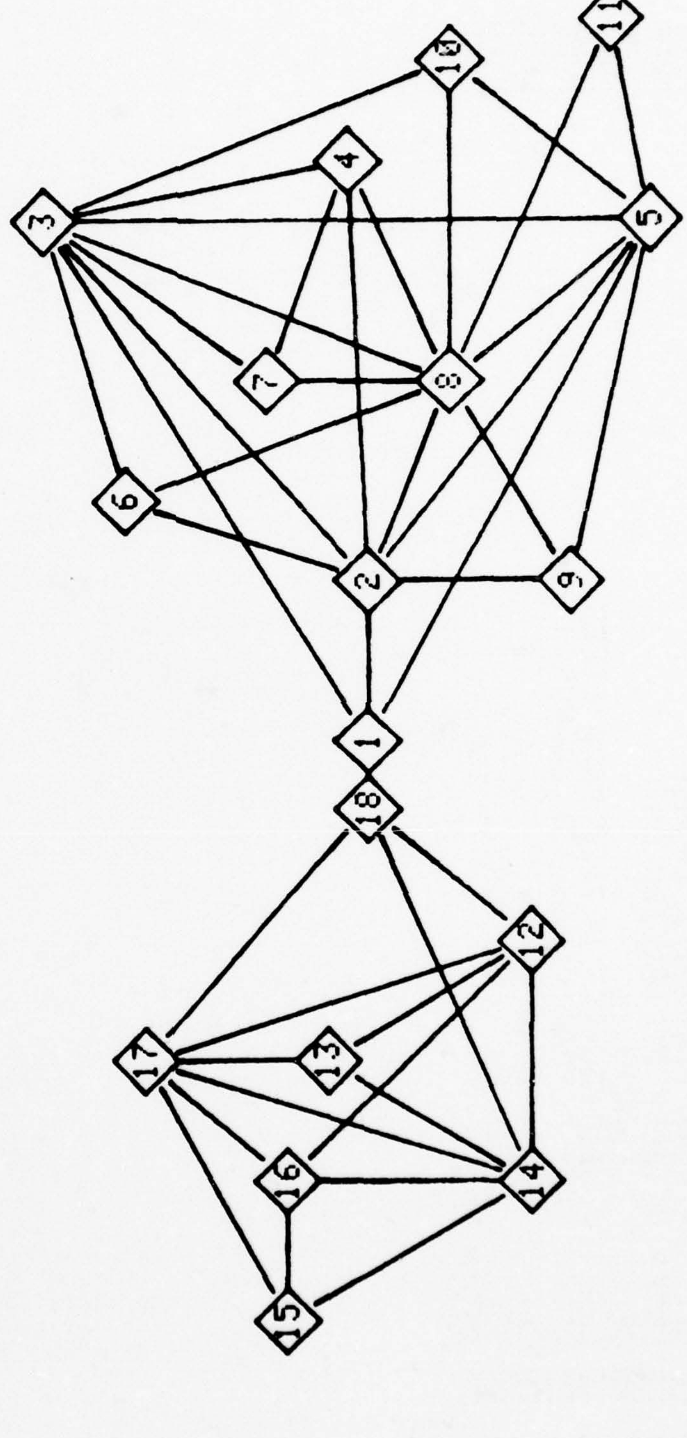
```
                GREETINGS FROM THE MARTIN MARIETTA AEROSPACE
                         HYBRID COMPUTER LABORATORY


                   - COMMUNICATIONS NETWORK SIMULATION -




TO CONTINUE... DEPRESS &lt;RETURN&gt; AFTER PLOTS, TABULAR OUTPUT, OR DATA ENTRY

TO COPY PARAMETERS FROM SIM TO CON                              TYPE  1
TO COPY PARAMETERS FROM CON TO SIM                              TYPE  2
TO LOAD REFINED DATA                                       TYPE  3 FILE.EXT
3 SAUERDCA.REF
```

```
                    ***NETWORK INITIALIZATION OPTIONS***

TO DISPLAY NETWORK DIAGRAM                                        TYPE  1
TO MAKE NETWORK PARAMETER CHANGE                                  TYPE  2
TO ENTER NETWORK DEFINITION DATA                                  TYPE  3
TO SELECT SCENARIO                                                TYPE  4
TO CHANGE INPUT/OUTPUT DEVICE PARAMETERS                          TYPE  5
TO ALLOW FREE FORMAT PARAMETER CHANGE                             TYPE  6
TO CHANGE REGISTER OPTIONS                                        TYPE  7
TO SELECT STRIP-PLOT OPTIONS                                      TYPE  8
TO BEGIN RUN                                                      TYPE  9
1
```

ØVERSEAS AUTØVØN NETWØRK

RUN 0

***** 0: 0: 0*****



```
                    ***NETWORK PARAMETER CHANGE***

FOR NO CHANGE                                                  TYPE  0

ENTER RUN NUMBER AS <XX,>

TO CHANGE RUN TIMING                                           TYPE  1
TO CHANGE TRAFFIC CHARACTERISTICS                              TYPE  2
TO CHANGE TABLE LIST PARAMETERS                                TYPE  3
1
```

```
                 ***CHANGE RUN TIMING PARAMETERS***
               (TO SKIP A PARAMETER, DEPRESS <RETURN>)

FOR NO CHANGE                                                TYPE  0

ENTER LENGTH OF RUN IN SECONDS AS <XXXXX,>

TO RUN SYNCHRONOUSLY WITH TIMER                              TYPE  1

ENTER NUMBER OF FRAMES PER MINUTE AS <XXX,>

ENTER NUMBER OF TIME INTERVALS PER FRAME INTERRUPT AS <XXX,>
```

```
                    ***CHANGE TRAFFIC CHARACTERISTICS***
                   (TO SKIP A PARAMETER, DEPRESS <RETURN>)

FOR NO CHANGE                                                    TYPE 0

ENTER NETWORK TRAFFIC MULTIPLICATION FACTOR AS <XX.XX,>

FOR SPILL FORWARD ROUTING WITH ORIGINATING OFFICE CONTROL        TYPE 1
FOR PRIMARY ONLY ROUTING                                         TYPE 2

TO ALLOW CALL PREMPTION                                          TYPE 3

TO ALLOW PREMPTED CALL REPLACEMENT                               TYPE 4

ENTER MAXIMUM NUMBER OF BLOCKED CALL REATTEMPTS AS <XX,>

ENTER AVERAGE CALL DURATION IN MINUTES AS <XX.XX,>

ENTER RANDOM CALL GENERATION STARTING SEQUENCE AS
<XXXX,XXXX,XXXX,XXXX,XXXX,XXXX,>

TO CHANGE AVERAGE RECALL TIMES                                   TYPE 5
```

CHANGE TABLE LIST PARAMETERS
(TO SKIP A PARAMETER, DEPRESS <RETURN>)

FOR NO CHANGE TYPE 0

ENTER 1ST, 2ND, AND 3RD LINK GOS ALARM THRESHOLDS AS
<X.XXX,X.XXX,X.XXX,>

ENTER 1ST, 2ND, AND 3RD NODE GOS ALARM THRESHOLDS AS
<X.XXX,X.XXX,X.XXX,>

```
                 ***NETWORK PARAMETER CHANGE***

FOR NO CHANGE                                                    TYPE  0
0
 **********RUN= 0**********

 NETWORK CONFIGURATION IS OVERSEAS
 RUN TIME      DATE=03/17/78  TIME=05:56:08
 RUN LENGTH (SEC) =  7200     SYNC INDICATOR = 0     TIME SCALE =  60
 RANDOM NUMBER SEEDS <IX0(6)> :
           1         101         1001          51          151          1051
 NUMBER FRAMES/MIN =   60     AVG CALL DURATION (MIN) =  6.00
 NUMBER TIME INTERVALS/FRAME =   1     SWITCH OPTIONS  7E100000
 LINKS =  41      NODES =  18     MAX CC =  256
 MAX PATHS/NODE =  4      MAX WORDS/NODE =  4
 ROUTING METHOD =  3
 TRAFFIC LOAD FACTOR =   1.00     MAX RECALLS =  0
 PREMPTED CALL REPLACEMENT = 0
 AVG TIME BETWEEN RECALLS 1-15 :
       0.25   2.00   6.75  16.00  31.25  54.00  85.75 128.00
     182.25 250.00 332.75 432.00 549.25 686.00 843.75
 NUMBER PRIORITIES = 5     ROUTINE PRECEDENCE = 4
 LOWEST PREMPTING PRIORITY = 3
 INPUT/OUTPUT DEVICE ASSIGNMENTS
   IUM,IUC,IUD,IUP,IUN,IULC,IULD,IURM,IURP  10 10 10 10 10 10 10 10 10
   OUM,OUC,OUD,OUP,OUN,OULC,OULD,OURM,OURP  11 11 11 11 11 11 11 11 11
   IPSUM,IPWRK,IPDOC,ICRD,ITEK,IOHCPY      12    12    12    13    3    3
 STRIPPLOT SETUP      TYPE/NUMBER
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16
 IDTST=  0  NST= 16  ICAL=100  OUSTR=  8
```

```
***NETWORK INITIALIZATION OPTIONS***

TO DISPLAY NETWORK DIAGRAM                                TYPE  1
TO MAKE NETWORK PARAMETER CHANGE                          TYPE  2
TO ENTER NETWORK DEFINITION DATA                          TYPE  3
TO SELECT SCENARIO                                        TYPE  4
TO CHANGE INPUT/OUTPUT DEVICE PARAMETERS                  TYPE  5
TO ALLOW FREE FORMAT PARAMETER CHANGE                     TYPE  6
TO CHANGE REGISTER OPTIONS                                TYPE  7
TO SELECT STRIP-PLOT OPTIONS                              TYPE  8
TO BEGIN RUN                                              TYPE  9
3
```

```
                         ***NETWORK DEFINITION***
FOR NO CHANGE                                                    TYPE  0
TO INPUT NEW DATA                                                TYPE  1
TO ALTER EXISTING DATA                                           TYPE  2
TO DESIGNATE SUBNETWORK                                          TYPE  3
1
 *INPUT DATA*1
                         ***NEW NETWORK DATA***

FOR NO CHANGE                                                    TYPE  0
FOR AUTOVON DATA                                                 TYPE  1
FOR AUTODIN DATA                                                 TYPE  2
FOR AUTOSEVOCOM DATA                                             TYPE  3
1
 *INPUT DATA*1

FOR NO DATA ENTRY                                                TYPE  0
TO ENTER DATA FROM CARDS                                         TYPE  1
TO ENTER DATA FROM MAG TAPE 1                                    TYPE  2
TO ENTER DATA FROM DISC                                          TYPE  3
TO LOAD REFINED DATA                                     TYPE  4 FILE.EXT
TO SAVE REFINED DATA                                     TYPE  5 FILE.EXT
5 SAVERDCA.REF
```

```
                         ***NETWORK DEFINITION***

FOR NO CHANGE                                                   TYPE  0
TO INPUT NEW DATA                                               TYPE  1
TO ALTER EXISTING DATA                                          TYPE  2
TO DESIGNATE SUBNETWORK                                         TYPE  3
1
                         ***NEW NETWORK DATA***

FOR NO CHANGE                                                   TYPE  0
FOR AUTOVON DATA                                                TYPE  1
FOR AUTODIN DATA                                                TYPE  2
FOR AUTOSEVOCOM DATA                                            TYPE  3
1

FOR NO DATA ENTRY                                               TYPE  0
TO ENTER DATA FROM CARDS                                        TYPE  1
TO ENTER DATA FROM MAG TAPE 1                                   TYPE  2
TO ENTER DATA FROM DISC                                         TYPE  3
3
                          *** LIST NEW DATA ***

NO DATA LIST                                                    TYPE  0
LIST TO LINE PRINTER                                            TYPE  1
LIST TO TEKTRONIX                                               TYPE  2
0
```

```
                    ***NETWORK DEFINITION***
FOR NO CHANGE                                          TYPE  0
TO INPUT NEW DATA                                      TYPE  1
TO ALTER EXISTING DATA                                 TYPE  2
TO DESIGNATE SUBNETWORK                                TYPE  3
2
 *INPUT DATA*2
                   *** ALTER NETWORK DATA ***

NO ALTER                                               TYPE  0
ALTER FROM TEKTRONIX                                   TYPE  1
ALTER FROM CARDS                                       TYPE  2
ALTER FROM MAG TAPE 1                                  TYPE  3
1
```

```
                    *** ALTER NETWORK DEFINITION DATA FROM TEKTRONIX ***

NO DATA ENTRY                                                           TYPE  0
TO ALTER LINK DEFINITION                                                TYPE  1
TO ALTER NODE DEFINITION                                                TYPE  2
TO ALTER CONNECTIVITY                                                   TYPE  3
TO ALTER CALL COMBINATIONS                                              TYPE  4
TO ALTER TRAFFIC LOADS                                                  TYPE  5
TO ALTER ROUTING                                                        TYPE  6
TO ALTER NETWORK PLOT COORDINATES                                       TYPE  7
TO PLOT NETWORK DIAGRAM                                                 TYPE  8
1
 *INPUT DATA*1
                    *** ALTER LINK DEFINITION ***

ENTER MAXIMUM NUMBER OF LINKS AS <XX,>

 *INPUT DATA*
ENTER <LINK> AND <NUMBER OF TRUNKS> AS <XX,XX,>
```

```
             *** ALTER NETWORK DEFINITION DATA FROM TEKTRONIX ***
NO DATA ENTRY                                                    TYPE  0
TO ALTER LINK DEFINITION                                         TYPE  1
TO ALTER NODE DEFINITION                                         TYPE  2
TO ALTER CONNECTIVITY                                            TYPE  3
TO ALTER CALL COMBINATIONS                                       TYPE  4
TO ALTER TRAFFIC LOADS                                           TYPE  5
TO ALTER ROUTING                                                 TYPE  6
TO ALTER NETWORK PLOT COORDINATES                                TYPE  7
TO PLOT NETWORK DIAGRAM                                          TYPE  8
2
 *INPUT DATA*2
                   *** ALTER NODE DEFINITION ***

ENTER MAXIMUM NUMBER OF NODES AS <XX,>

 *INPUT DATA*
ENTER <NODE> AND <SWITCH CAPACITY> AS <XX,XXX,>
```

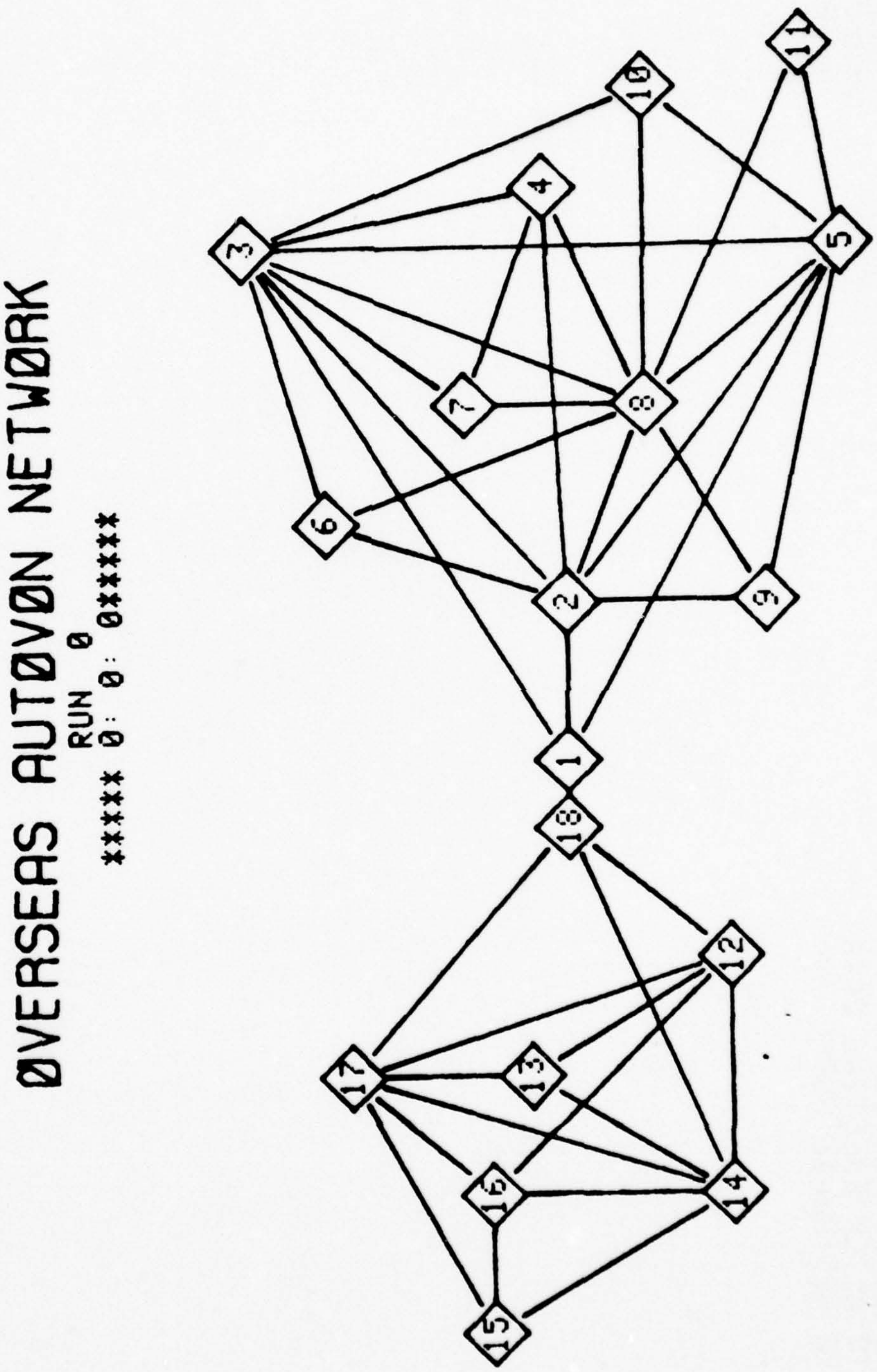
```
          *** ALTER NETWORK DEFINITION DATA FROM TEKTRONIX ***

NO DATA ENTRY                                                     TYPE  0
TO ALTER LINK DEFINITION                                          TYPE  1
TO ALTER NODE DEFINITION                                          TYPE  2
TO ALTER CONNECTIVITY                                             TYPE  3
TO ALTER CALL COMBINATIONS                                        TYPE  4
TO ALTER TRAFFIC LOADS                                            TYPE  5
TO ALTER ROUTING                                                  TYPE  6
TO ALTER NETWORK PLOT COORDINATES                                 TYPE  7
TO PLOT NETWORK DIAGRAM                                           TYPE  8
3
 *INPUT DATA*3
                    *** ALTER CONNECTIVITY ***

ENTER <LINK>, <SOURCE NODE>, AND <DESTINATION NODE> AS
<XX,XX,XX,>
```

```
                    *** ALTER NETWORK DEFINITION DATA FROM TEKTRONIX ***
NO DATA ENTRY                                                          TYPE  0
TO ALTER LINK DEFINITION                                               TYPE  1
TO ALTER NODE DEFINITION                                               TYPE  2
TO ALTER CONNECTIVITY                                                  TYPE  3
TO ALTER CALL COMBINATIONS                                             TYPE  4
TO ALTER TRAFFIC LOADS                                                 TYPE  5
TO ALTER ROUTING                                                       TYPE  6
TO ALTER NETWORK PLOT COORDINATES                                      TYPE  7
TO PLOT NETWORK DIAGRAM                                                TYPE  8
4
 *INPUT DATA*4
                          *** ALTER CALL COMBINATIONS ***

ENTER <CALL COMBINATION>, <SOURCE NODE>, AND <DESTINATION NODE>
AS <XX,XX,XX,>
```

```
*** ALTER NETWORK DEFINITION DATA FROM TEKTRONIX ***

NO DATA ENTRY                                            TYPE  0
TO ALTER LINK DEFINITION                                 TYPE  1
TO ALTER NODE DEFINITION                                 TYPE  2
TO ALTER CONNECTIVITY                                    TYPE  3
TO ALTER CALL COMBINATIONS                               TYPE  4
TO ALTER TRAFFIC LOADS                                   TYPE  5
TO ALTER ROUTING                                         TYPE  6
TO ALTER NETWORK PLOT COORDINATES                        TYPE  7
TO PLOT NETWORK DIAGRAM                                  TYPE  8
5
 *INPUT DATA*5
                  *** ALTER TRAFFIC LOADS ***

ENTER <CALL COMBINATION>, <PRIORITY>, AND <TRAFFIC LOAD> AS
<XXX,X,XX.XXX,E,> WHERE <E> DENOTES TRAFFIC LOAD IS IN ERLANGS
  60 0.600E+01 0.100E+01 0.041E-01-0.360E+03-0.130E+05

 *INPUT DATA*
TO DISPLAY TRAFFIC TABLE                                 TYPE  1
1
```

```
           *** ALTER NETWORK DEFINITION DATA FROM TEKTRONIX ***

NO DATA ENTRY                                                   TYPE  0
TO ALTER LINK DEFINITION                                        TYPE  1
TO ALTER NODE DEFINITION                                        TYPE  2
TO ALTER CONNECTIVITY                                           TYPE  3
TO ALTER CALL COMBINATIONS                                      TYPE  4
TO ALTER TRAFFIC LOADS                                          TYPE  5
TO ALTER ROUTING                                                TYPE  6
TO ALTER NETWORK PLOT COORDINATES                               TYPE  7
TO PLOT NETWORK DIAGRAM                                         TYPE  8
6
 *INPUT DATA*6
                  *** ALTER ROUTING DEFINITION ***

ENTER <SOURCE NODE>, <DESTINATION NODE>, <1ST NODE IN PATH 1>,
<SI>, <1ST NODE IN PATH 2>, <SI>, 1ST NODE IN PATH 3>, <SI>, ....
AS <XX,XX,XX,X,XX,X,XX,X,...
WHERE SI = 0 FOR SPILL FORWARD NODE
         = 1,2, ... N, FOR NUMBER OF ROUTES OUT OF TANDEM NODE

 *INPUT DATA*
TO DISPLAY ROUTING TABLE                                        TYPE  1
1 1 5 1 5
```

```
                 *** ALTER NETWORK DEFINITION DATA FROM TEKTRONIX ***

NO DATA ENTRY                                                      TYPE  0
TO ALTER LINK DEFINITION                                           TYPE  1
TO ALTER NODE DEFINITION                                           TYPE  2
TO ALTER CONNECTIVITY                                              TYPE  3
TO ALTER CALL COMBINATIONS                                         TYPE  4
TO ALTER TRAFFIC LOADS                                             TYPE  5
TO ALTER ROUTING                                                   TYPE  6
TO ALTER NETWORK PLOT COORDINATES                                  TYPE  7
TO PLOT NETWORK DIAGRAM                                            TYPE  8
7
 *INPUT DATA*7
                        *** ALTER PLOT COORDINATES ***

ENTER <NODE>, <X COORDINATE>, <Y COORDINATE>, AND <NETWORK
DESIGNATOR> AS <XX,XX.XX,XX.XX,,D,> WHERE X(MAX) = 37.,
Y(MAX) = 27., AND NETWORK DESIGNATOR = E,P, OR O.
```


ØVERSEAS AUTØVØN NETWØRK
RUN 0
***** 0: 0: 0*****
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

```
                    ***NETWORK DEFINITION***
FOR NO CHANGE                                          TYPE  0
TO INPUT NEW DATA                                      TYPE  1
TO ALTER EXISTING DATA                                 TYPE  2
TO DESIGNATE SUBNETWORK                                TYPE  3
3
```

```
IF SELECTION IS COMPLETE                                        TYPE  0
FOR OVERSEAS AUTOVON                                            TYPE  1
FOR PACIFIC AUTOVON                                             TYPE  2
FOR EUROPEAN AUTOVON                                            TYPE  3
FOR AUTODIN I                                                   TYPE  4
FOR AUTODIN II                                                  TYPE  5
FOR DSCS                                                        TYPE  6
1
 *INPUT DATA*1
IF SELECTION IS COMPLETE                                        TYPE  0
FOR OVERSEAS AUTOVON                                            TYPE  1
FOR PACIFIC AUTOVON                                             TYPE  2
FOR EUROPEAN AUTOVON                                            TYPE  3
FOR AUTODIN I                                                   TYPE  4
FOR AUTODIN II                                                  TYPE  5
FOR DSCS                                                        TYPE  6
0
 *INPUT DATA*0
CONFIGURATION SELECTED IS:
                              OVERSEAS AUTOVON

IF SELECTION IS COMPLETE                                        TYPE  1
1
```

```
                         ***NETWORK DEFINITION***

FOR NO CHANGE                                                      TYPE  0
TO INPUT NEW DATA                                                  TYPE  1
TO ALTER EXISTING DATA                                             TYPE  2
TO DESIGNATE SUBNETWORK                                            TYPE  3
0
 *INPUT DATA*0
 **********RUN= 0**********

 NETWORK CONFIGURATION IS OVERSEAS
 RUN TIME     DATE=03/30/78  TIME=13:01:04
 RUN LENGTH (SEC) =  7200    SYNC INDICATOR = 1     TIME SCALE =  60
 RANDOM NUMBER SEEDS <IX0(6)> :
          1         101        1001        51         151          1051
 NUMBER FRAMES/MIN =   60    AVG CALL DURATION (MIN) =  6.00
 NUMBER TIME INTERVALS/FRAME =   1     SWITCH OPTIONS:  7E100000
 LINKS = 41    NODES = 18    MAX CC = 256    MAX PATHS(WORDS)/NODE = 4(4)
 ROUTING METHOD =  3     TRAFFIC LOAD FACTOR =   1.00
 MAX RECALLS =  0    PREMPTED CALL REPLACEMENT = 0
 AVG TIME BETWEEN RECALLS 1-15 :
      0.25   2.00   6.75  16.00  31.25  54.00  85.75 128.00
    182.25 250.00 332.75 432.00 549.25 686.00 843.75
 PRIORITIES = 5   ROUTINE PRECEDENCE = 4   LOWEST PREMPTING PRIORITY = 3
 INPUT/OUTPUT DEVICE ASSIGNMENTS
   IUM,IUC,IUD,IUP,IUN,IULC,IULD,IURM,IURP  10 10 10 10 10 10 10 10 10
   OUM,OUC,OUD,OUP,OUN,OULC,OULD,OURM,OURP  11 11 11 11 11 11 11 11 11
   IPSUM,IPWRK,IPDOC,ICRD,ITEK,IOHCPY      12   12   12   13    3    3
 STRIPPLOT SETUP     TYPE/NUMBER
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16
 IDTST=  1  NST= 16  ICAL=  0  OUSTR=  8
```

```
                    *** CHANGE INPUT/OUTPUT DEVICES ***

FOR NO CHANGE                                                     TYPE  0
TO CHANGE INPUT DEVICES                                           TYPE  1
TO CHANGE OUTPUT DEVICES                                          TYPE  2
TO CHANGE TEKTRONIX OPTIONS                                       TYPE  3
TO COPY I/O OPTIONS FROM SIM                                      TYPE  4
TO COPY I/O OPTIONS TO   SIM                                      TYPE  5
1
                       *** INPUT DEVICE CHANGE ***

ENTER DEVICE NUMBERS FOR MAIN, CONTROL, DATAIN, PARAMETER CHANGE
NODE CONTROL, LINK CAPACITY, LINK DIRECTIONALIZATION, ROUTING
METHOD, AND ROUTING PLAN ROUTINES AS <XX,XX,XX,XX,XX,XX,XX,XX,XX,>

ENTER ICRD DEVICE DESIGNATION AS <XX,>
WHERE:  CARD READER = 10 OR 13
        MAG TAPE 1 = 14
        TEKTRONIX = 15
```

```
                  *** CHANGE INPUT/OUTPUT DEVICES ***

FOR NO CHANGE                                                 TYPE  0
TO CHANGE INPUT DEVICES                                       TYPE  1
TO CHANGE OUTPUT DEVICES                                      TYPE  2
TO CHANGE TEKTRONIX OPTIONS                                   TYPE  3
TO COPY I/O OPTIONS FROM SIM                                  TYPE  4
TO COPY I/O OPTIONS TO   SIM                                  TYPE  5
2
                     *** OUTPUT DEVICE CHANGE ***

ENTER DEVICE NUMBERS FOR MAIN, CONTROL, DATAIN, PARAMETER CHANGE
NODE CONTROL, LINK CAPACITY, LINK DIRECTIONALIZATION, ROUTING
METHOD, AND ROUTING PLAN ROUTINES AS <XX,XX,XX,XX,XX,XX,XX,XX,XX,>

ENTER DEVICES TO WHICH RUN SUMMARY, RUN STATISTICS, AND
DOCUMENTATION ARE TO BE OUTPUT AS <XX,XX,XX,>

ENTER ITEK DEVICE OUTPUT DESIGNATION AS <XX,>
WHERE:   LINE PRINTER = 11
         MAG TAPE 1 = 14
         TEKTRONIX = 15
```

```
                    *** CHANGE INPUT/OUTPUT DEVICES ***

FOR NO CHANGE                                                      TYPE  0
TO CHANGE INPUT DEVICES                                            TYPE  1
TO CHANGE OUTPUT DEVICES                                           TYPE  2
TO CHANGE TEKTRONIX OPTIONS                                        TYPE  3
TO COPY I/O OPTIONS FROM SIM                                       TYPE  4
TO COPY I/O OPTIONS TO   SIM                                       TYPE  5
3
                      *** TEKTRONIX OPTION CHANGE ***

ENTER BAUD RATE AS <XXXX,>

ENTER HARDCOPY SELECTION DEVICE AS <XX,>

SELECT NETWORK PLOT HARDCOPY OPTION:
    NO HARDCOPY                                                    TYPE  0
    AUTOMATIC HARDCOPY                                             TYPE  1
    MANUAL HARDCOPY                                                TYPE  2

SELECT TEXT HARDCOPY OPTION:
    NO HARDCOPY                                                    TYPE  0
    AUTOMATIC HARDCOPY                                             TYPE  1
    MANUAL HARDCOPY                                                TYPE  2
```

```
                    *** CHANGE REGISTER OPTIONS ***

FOR NO CHANGE                                                   TYPE  0
TO LIST CURRENT REGISTER OPTIONS                                TYPE  1
TO SET REGISTER OPTIONS                                         TYPE  2
TO RESET REGISTER OPTIONS                                       TYPE  3
TO COPY REGISTER FROM SIM                                         TYPE 4
1
   1 ISPRO   (0)     2 ISPNN   (1)     3 ISPPU   (1)     4 ISPLNG  (1)
   5 ISPTT   (1)     6 ISPNP   (1)     7 IS07    (1)     8 ISTME   (0)
   9 ISPLOT  (0)    10 IST100  (0)    11 ISXPRG  (0)    12 ISDOC   (1)
  13 ISDAT   (0)    14 IS14    (0)    15 IS15    (0)    16 IS16    (0)
  17 ISDBTM  (0)    18 ISDBLR  (0)    19 ISDBNR  (0)    20 ISDBAN  (0)
  21 ISDBRT  (0)    22 ISDBCS  (0)    23 ISDBBC  (0)    24 ISDBPR  (0)
  25 ISDBLP  (0)    26 ISDBLL  (0)    27 IS27    (0)    28 IS28    (0)
  29 IS29    (0)    30 IS30    (0)    31 IS31    (0)    32 IS32    (0)
                    *** CHANGE REGISTER OPTIONS ***

FOR NO CHANGE                                                   TYPE  0
TO LIST CURRENT REGISTER OPTIONS                                TYPE  1
TO SET REGISTER OPTIONS                                         TYPE  2
TO RESET REGISTER OPTIONS                                       TYPE  3
TO COPY REGISTER FROM SIM                                         TYPE 4
```

```
                    *** SELECT STRIP-PLOT OPTIONS ***

FOR NO CHANGE                                               TYPE  0
TO SELECT LINK LOAD CHANNELS                                TYPE  1
TO SELECT NODE LOAD CHANNELS                                TYPE  2
TO SELECT EVENT MARKER CHANNELS                             TYPE  3
TO SELECT GOS CHANNELS                                      TYPE  4
TO SPECIFY TYPE OF NETWORK GOS                              TYPE  5
TO SELECT STRIP-PLOT INITIALIZATION OPTIONS                 TYPE  6
TO DISPLAY STRIP-PLOT CHANNEL CONFIGURATION                 TYPE  7
TO COPY STRIP-PLOT PARAMETERS FROM SIM                     TYPE 8
1
ENTER <CHANNEL NUMBER AND LINK> AS <XX,XX,><XX,XX,> ...
1,1,2,1,3,1,
                    *** SELECT STRIP-PLOT OPTIONS ***

FOR NO CHANGE                                               TYPE  0
TO SELECT LINK LOAD CHANNELS                                TYPE  1
TO SELECT NODE LOAD CHANNELS                                TYPE  2
TO SELECT EVENT MARKER CHANNELS                             TYPE  3
TO SELECT GOS CHANNELS                                      TYPE  4
TO SPECIFY TYPE OF NETWORK GOS                              TYPE  5
TO SELECT STRIP-PLOT INITIALIZATION OPTIONS                 TYPE  6
TO DISPLAY STRIP-PLOT CHANNEL CONFIGURATION                 TYPE  7
TO COPY STRIP-PLOT PARAMETERS FROM SIM                     TYPE 8
2
ENTER <CHANNEL NUMBER AND NODE> AS <XX,XX,><XX,XX,> ...
4,1,5,1,6,1,
```

```
3
ENTER EVENT MARK CHANNEL NUMBER AS <XX,>

                    *** SELECT STRIP-PLOT OPTIONS ***

FOR NO CHANGE                                                   TYPE  0
TO SELECT LINK LOAD CHANNELS                                    TYPE  1
TO SELECT NODE LOAD CHANNELS                                    TYPE  2
TO SELECT EVENT MARKER CHANNELS                                 TYPE  3
TO SELECT GOS CHANNELS                                          TYPE  4
TO SPECIFY TYPE OF NETWORK GOS                                  TYPE  5
TO SELECT STRIP-PLOT INITIALIZATION OPTIONS                     TYPE  6
TO DISPLAY STRIP-PLOT CHANNEL CONFIGURATION                     TYPE  7
TO COPY STRIP-PLOT PARAMETERS FROM SIM                          TYPE  8
4
                      *** SELECT GOS CHANNELS ***

ENTER CHANNEL NUMBER, LINK, AND GOS TYPE AS <XX,XX,XX,>
2,1,2,
ENTER CHANNEL NUMBER, NODE, AND GOS TYPE AS <XX,XX,XX,>
5,1,5,
ENTER CHANNEL NUMBER AND TYPE FOR TOTAL NETWORK GOS AS <XX,XX,>

ENTER CHANNEL NUMBER, PRIORITY (0-4), AND TYPE OF NETWORK GOS AS
<XX,X,XX,>
7,4,7,8,4,8,
```

```
                    *** SELECT STRIP-PLOT OPTIONS ***

FOR NO CHANGE                                                      TYPE 0
TO SELECT LINK LOAD CHANNELS                                       TYPE 1
TO SELECT NODE LOAD CHANNELS                                       TYPE 2
TO SELECT EVENT MARKER CHANNELS                                    TYPE 3
TO SELECT GOS CHANNELS                                             TYPE 4
TO SPECIFY TYPE OF NETWORK GOS                                     TYPE 5
TO SELECT STRIP-PLOT INITIALIZATION OPTIONS                        TYPE 6
TO DISPLAY STRIP-PLOT CHANNEL CONFIGURATION                        TYPE 7
TO COPY STRIP-PLOT PARAMETERS FROM SIM                             TYPE 8
FOR DEFINITION OF STRIP-PLOT TYPES                                 TYPE 9
5
 *INPUT DATA*5
                   *** SPECIFY TYPE OF NETWORK GOS ***

ENTER NUMBER OF DATA BASE FRAMES PER STRIP-PLOT INTERVAL
(LINK OR NODE GOS) AS <XXX,>

 *INPUT DATA*
ENTER NUMBER OF PLOT INTERVALS PER GOS WINDOW AS <XXX,>

 *INPUT DATA*
ENTER PAST HISTORY WEIGHTING FACTOR AS <XX.XX,>
```

```
 *INPUT DATA*
                         *** SELECT STRIP-PLOT OPTIONS ***

FOR NO CHANGE                                                      TYPE  0
TO SELECT LINK LOAD CHANNELS                                       TYPE  1
TO SELECT NODE LOAD CHANNELS                                       TYPE  2
TO SELECT EVENT MARKER CHANNELS                                    TYPE  3
TO SELECT GOS CHANNELS                                             TYPE  4
TO SPECIFY TYPE OF NETWORK GOS                                     TYPE  5
TO SELECT STRIP-PLOT INITIALIZATION OPTIONS                        TYPE  6
TO DISPLAY STRIP-PLOT CHANNEL CONFIGURATION                        TYPE  7
TO COPY STRIP-PLOT PARAMETERS FROM SIM                             TYPE  8
FOR DEFINITION OF STRIP-PLOT TYPES                                 TYPE  9
6
 *INPUT DATA*6
ENTER <NUMBER OF STRIP-PLOT CHANNELS>, <NUMBER OF FRAMES PER
STRIP-PLOT INTERVAL>, AND <OUTPUT UNIT NUMBER> AS <XX,XXX,XX,>

 *INPUT DATA*
ENTER CALIBRATION STEP SIZE IN PERCENT OF FULL SCALE AS <XXX,>
```

```
                    *** SELECT STRIP-PLOT OPTIONS ***

FOR NO CHANGE                                                  TYPE  0
TO SELECT LINK LOAD CHANNELS                                   TYPE  1
TO SELECT NODE LOAD CHANNELS                                   TYPE  2
TO SELECT EVENT MARKER CHANNELS                                TYPE  3
TO SELECT GOS CHANNELS                                         TYPE  4
TO SPECIFY TYPE OF NETWORK GOS                                 TYPE  5
TO SELECT STRIP-PLOT INITIALIZATION OPTIONS                    TYPE  6
TO DISPLAY STRIP-PLOT CHANNEL CONFIGURATION                    TYPE  7
TO COPY STRIP-PLOT PARAMETERS FROM SIM                         TYPE  8
FOR DEFINITION OF STRIP-PLOT TYPES                             TYPE  9
7
 *INPUT DATA*7
 STRIP-PLOT SETUP     TYPE/NUMBER
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16
 IDTST=  1  NST= 16   ICAL=  0  OUSTR=  8
                    *** SELECT STRIP-PLOT OPTIONS ***

FOR NO CHANGE                                                  TYPE  0
TO SELECT LINK LOAD CHANNELS                                   TYPE  1
TO SELECT NODE LOAD CHANNELS                                   TYPE  2
TO SELECT EVENT MARKER CHANNELS                                TYPE  3
TO SELECT GOS CHANNELS                                         TYPE  4
TO SPECIFY TYPE OF NETWORK GOS                                 TYPE  5
TO SELECT STRIP-PLOT INITIALIZATION OPTIONS                    TYPE  6
TO DISPLAY STRIP-PLOT CHANNEL CONFIGURATION                    TYPE  7
TO COPY STRIP-PLOT PARAMETERS FROM SIM                         TYPE  8
FOR DEFINITION OF STRIP-PLOT TYPES                             TYPE  9
```

```
                    *** SELECT STRIP-PLOT OPTIONS ***
FOR NO CHANGE                                                 TYPE  0
TO SELECT LINK LOAD CHANNELS                                  TYPE  1
TO SELECT NODE LOAD CHANNELS                                  TYPE  2
TO SELECT EVENT MARKER CHANNELS                               TYPE  3
TO SELECT GOS CHANNELS                                        TYPE  4
TO SPECIFY TYPE OF NETWORK GOS                                TYPE  5
TO SELECT STRIP-PLOT INITIALIZATION OPTIONS                   TYPE  6
TO DISPLAY STRIP-PLOT CHANNEL CONFIGURATION                   TYPE  7
TO COPY STRIP-PLOT PARAMETERS FROM SIM                        TYPE  8
FOR DEFINITION OF STRIP-PLOT TYPES                            TYPE  9
9
 *INPUT DATA*9
   TYPE          DESCRIPTION

     1     LINK PERCENT UTILIZATION
     2     LINK GOS (ACCUMULATED)
     3     LINK GOS (WINDOWED)
     4     NODE PERCENT UTILIZATION
     5     NODE GOS (ACCUMULATED)
     6     NODE GOS (WINDOWED)
     7     NETWORK GOS BY PRIORITY (ACCUMULATED)
     8     NETWORK GOS BY PRIORITY (WINDOWED)
     9     TOTAL NETWORK GOS (ACCUMULATED)
    10     TOTAL NETWORK GOS (WINDOWED)
                    *** SELECT STRIP-PLOT OPTIONS *
```

```
                        *** RUN OPTIONS ***

TO START NORMAL RUN                                                TYPE  1
TO TERMINATE RUN AND REEXECUTE                                     TYPE  2
TO INITIATE CONTROLLER INTERACTION                                 TYPE  3
TO INITIATE NETWORK PERTURBATION                                   TYPE  4
TO CHANGE PROGRAM TIME SCALE                                       TYPE  5
TO PARTIALLY INITIALIZE NETWORK AND ENVIRONMENT AND THEN RUN       TYPE  6
TO ABORT PROGRAM EXECUTION                                         TYPE  9
1
 *INPUT DATA*1
 **********RUN= 1**********

 NETWORK CONFIGURATION IS OVERSEAS
 RUN TIME      DATE=03/30/78  TIME=15:58:25
 RUN LENGTH (SEC) =  7200      SYNC INDICATOR = 1      TIME SCALE =  60
 RANDOM NUMBER SEEDS <IX0(6)> :
          1          101          1001          51          151          1051
 NUMBER FRAMES/MIN =   60      AVG CALL DURATION (MIN) =  6.00
 NUMBER TIME INTERVALS/FRAME =   1      SWITCH OPTIONS:  7E100000
 LINKS = 41    NODES = 18    MAX CC = 256    MAX PATHS(WORDS)/NODE = 4(4)
 ROUTING METHOD =  3     TRAFFIC LOAD FACTOR =   1.00
 MAX RECALLS =  0     PREMPTED CALL REPLACEMENT = 0
 AVG TIME BETWEEN RECALLS 1-15 :
     0.25   2.00   6.75  16.00  31.25  54.00  85.75 128.00
   182.25 250.00 332.75 432.00 549.25 686.00 843.75
 PRIORITIES = 5   ROUTINE PRECEDENCE = 4   LOWEST PREMPTING PRIORITY = 3
 INPUT/OUTPUT DEVICE ASSIGNMENTS
   IUM,IUC,IUD,IUP,IUN,IULC,IULD,IURM,IURP  10 10 10 10 10 10 10 10 10
   OUM,OUC,OUD,OUP,OUN,OULC,OULD,OURM,OURP  11 11 11 11 11 11 11 11 11
   IPSUM,IPWRK,IPDOC,ICRD,ITEK,IOHCPY      12   12   12   13   3   3
 STRIPPLOT SETUP      TYPE/NUMBER
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16
 IDTST=  1  NST= 16  ICAL=  0  OUSTR=  8
```

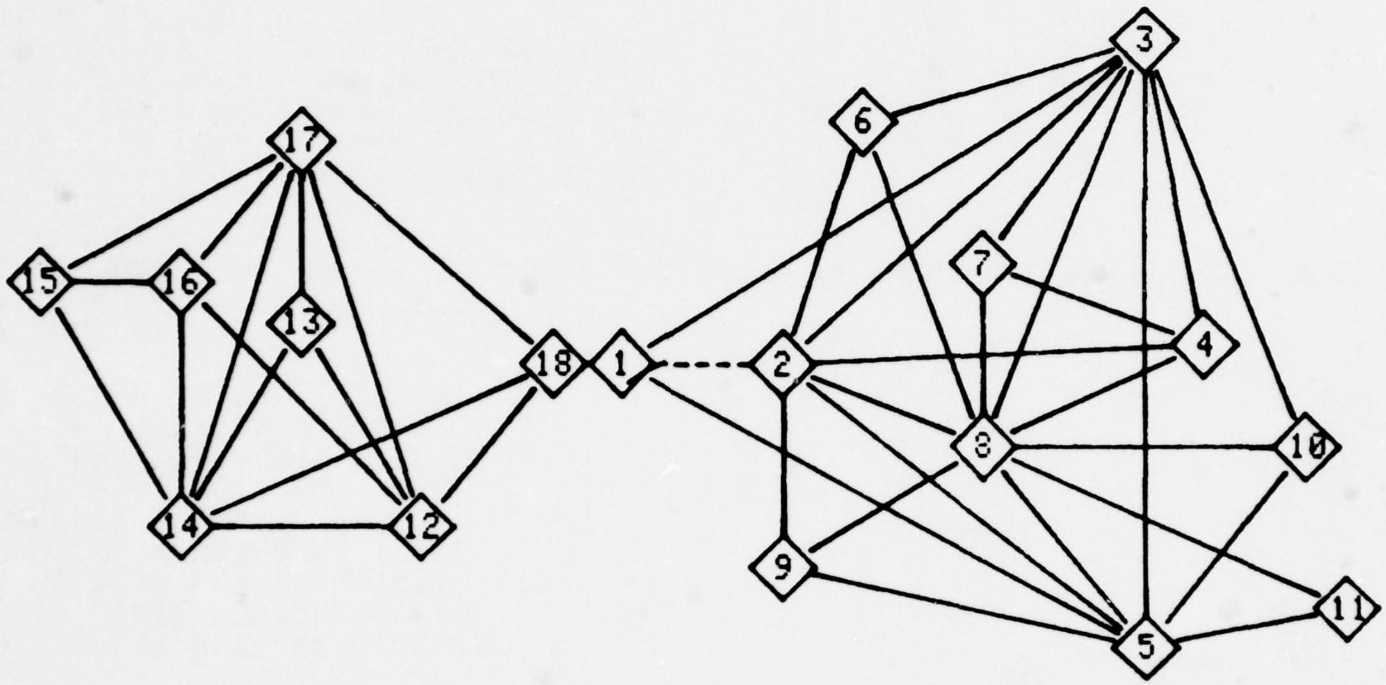
```
                         *** RUN OPTIONS ***
TO START NORMAL RUN                                              TYPE  1
TO TERMINATE RUN AND REEXECUTE                                   TYPE  2
TO INITIATE CONTROLLER INTERACTION                               TYPE  3
TO INITIATE NETWORK PERTURBATION                                 TYPE  4
TO CHANGE PROGRAM TIME SCALE                                     TYPE  5
TO PARTIALLY INITIALIZE NETWORK AND ENVIRONMENT AND THEN RUN     TYPE  6
TO ABORT PROGRAM EXECUTION                                       TYPE  9
3
 *INPUT DATA*3
                *** CONTROLLER INTERACTION MODE ***

TO DISPLAY NETWORK DIAGRAM                                       TYPE  1
TO INITIATE CONTROL ACTION                                       TYPE  2
TO DISPLAY NETWORK STATISTICS                                    TYPE  3
TO DISPLAY NETWORK STATUS                                        TYPE  4
TO RESET GOS DATA BASE                                           TYPE  5
TO DISPLAY ROUTING TABLE                                         TYPE  6
TO CLEAR TEKTRONIX SCREEN                                        TYPE  7
TO COPY TEKTRONIX SCREEN                                         TYPE  8
TO RETURN TO RUN OPTIONS                                         TYPE  9
1
```

ØVERSEAS AUTØVØN NETWØRK

RUN 3

***** 0:42:29*****

DASHED LINE INDICATES OUT OF SERVICE EQUIPMENT



```
*INPUT DATA*3
                    *** CONTROLLER INTERACTION MODE ***

TO DISPLAY NETWORK DIAGRAM                                            TYPE  1
TO INITIATE CONTROL ACTION                                            TYPE  2
TO DISPLAY NETWORK STATISTICS                                         TYPE  3
TO DISPLAY NETWORK STATUS                                             TYPE  4
TO RESET GOS DATA BASE                                                TYPE  5
TO DISPLAY ROUTING TABLE                                              TYPE  6
TO CLEAR TEKTRONIX SCREEN                                             TYPE  7
TO COPY TEKTRONIX SCREEN                                              TYPE  8
TO RETURN TO RUN OPTIONS                                              TYPE  9
2
 *INPUT DATA*2
 *CONTROL IMPLEMENTATION*
 ENTER NEGATIVE NUMBER TO QUEUE AND POSITIVE NUMBER TO IMPLEMENT THIS AND
 OTHERQUEUED CONTROLS
 TO RESET ALL CONTROLS                        RES  TYPE  1 OR  -1
 FOR DESTINATION CODE CANCELLATION            DCC  TYPE  2 OR  -2
 FOR LINE LOAD CONTROL                        LLC  TYPE  3 OR  -3
 FOR LINK DIRECTIONALIZATION                  LDR  TYPE  4 OR  -4
 FOR LINK ACCESS BY PRECEDENCE                LAP  TYPE  5 OR  -5
 FOR PRIMARY ONLY OR LIMITED ROUTING          PRO  TYPE  6 OR  -6
 TO ALTER ROUTING TABLE                       ART  TYPE  7 OR  -7
 TO RESTORE NOMINAL ROUTING TABLE             RRT  TYPE  8 OR  -8
 TO IMPLEMENT QUEUED CONTROLS                      TYPE       -99
 TO DELETE QUEUE                                   TYPE 99
 TO TERMINATE CONTROL INPUT                        TYPE A BLANK
 ENTER CONTROL TYPE
2
```

```
*INPUT DATA*2
*DESTINATION CODE CANCELLATION FROM NODE *NS* TO NODE *ND* AT AND
BELOW PRIORITY *IP*.
IF(NS.LE.0) THEN ALL SOURCES TO *ND* WILL BE CANCELLED.
ENTER BLANK LINE TO TERMINATE ROUTINE.
TYPE: NS ND IP

*INPUT DATA*
                              ***** 0:30:59*****
ENTER CONTROL TYPE
3
*INPUT DATA*3
*LINE LOAD CONTROL OF *IPC* PERCENT OF TRAFFIC AT PRIORITY *IP* (AND OF
ALL LOWER PRIORITY TRAFFIC) AT NODE *NS*.
IF(IPC.LE.0) THEN ALL OF PRIORITY *IP* RESTRICTED.
ENTER BLANK LINE TO TERMINATE ROUTINE.
TYPE: NS IP IPC

*INPUT DATA*
                              ***** 0:30:59*****
ENTER CONTROL TYPE
4
*INPUT DATA*4
*LINK DIRECTIONALIZATION OF LINK *L* FROM NODE *NS*. *NOL* IS NUMBER OF TRUNKS

RESERVED FOR PREFERRED DIRECTION FROM *NS*.
IF(NOL.LE.0) THEN 100 PERCENT DIRECTIONALIZATION IMPOSED.
ENTER BLANK LINE TO TERMINATE ROUTINE.
TYPE: L NS NOL

*INPUT DATA*
                              ***** 0:30:59*****
ENTER CONTROL TYPE
5
```

```
*INPUT DATA*5
*LINK ACCESS RESTRICTION OF LINK *L* FROM NODE *NS*. ALL TRAFFIC OF PRIORITY

EQUAL TO OR LOWER THAN *IP* IS DENIED ACCESS.
IF(NS.LE.0) THEN BOTH DIRECTIONS ARE RESTRICTED.
ENTER BLANK LINE TO TERMINATE ROUTINE.
TYPE: L NS IP

*INPUT DATA*
                          ***** 0:30:59*****
ENTER CONTROL TYPE
6
*INPUT DATA*6
*ROUTING RESTRICTION FOR NODES *N1*-*N2*,    *ALT* IS MAXIMUM NUMBER OF ALTERNATE
 ALLOWED
*ALT*=0 OR 1 FOR PRIMARY ONLY ROUTING.
IF(N1.LT.0) THEN RESTRICTION FOR ALL NODES.
ENTER BLANK LINE TO TERMINATE ROUTINE.
TYPE: N1 N2 ALT

*INPUT DATA*
                          ***** 0:30:59*****
ENTER CONTROL TYPE
7
```

```
*INPUT DATA*7
*ALTER ROUTING TABLE FROM NODE *NS* TO NODE *ND* WHERE *NI* AND *SI*,
WHERE I=1,MPPN,ARE RESPECTIVELY TANDEM NODE AND SPILL
INDICATOR FOR THE I-TH PATH CONNECTING *NS* AND *ND*
IF(NI.LT.0) THEN I-TH PATH WILL BE LEFT UNCHANGED.
ENTER BLANK LINE TO TERMINATE ROUTINE.
TYPE: NS ND NT1 S1 NT2 S2 NT3 S3 ...

*INPUT DATA*
                              ***** 0:30:59*****
*ROUTING TABLE FOR NODES *NS* TO *ND* WITH TANDEM PATH NODES *NTI**
              *AND SPILL INDICATORS *SI* FOR PATHS *I**
 NS ND  NT1:S  NT2:S  NT3:S  NT4:S
ENTER CONTROL TYPE
1
*INPUT DATA*1
                              ***** 0:30:59*****
*ALL CONTROLS RESET*
ENTER CONTROL TYPE
```

```
*INPUT DATA*3
                    *** CONTROLLER INTERACTION MODE ***

TO DISPLAY NETWORK DIAGRAM                                       TYPE  1
TO INITIATE CONTROL ACTION                                       TYPE  2
TO DISPLAY NETWORK STATISTICS                                    TYPE  3
TO DISPLAY NETWORK STATUS                                        TYPE  4
TO RESET GOS DATA BASE                                           TYPE  5
TO DISPLAY ROUTING TABLE                                         TYPE  6
TO CLEAR TEKTRONIX SCREEN                                        TYPE  7
TO COPY TEKTRONIX SCREEN                                         TYPE  8
TO RETURN TO RUN OPTIONS                                         TYPE  9
3
*INPUT DATA*3
                         *** NETWORK STATISTICS ***

TO DISPLAY USER STATISTICS                                       TYPE  0
TO DISPLAY NODE OCCUPANCY                                        TYPE  1
TO DISPLAY NODE OCCUPANCY BY SOURCE-TANDEM/DESTINATION AND
  PRIORITY                                                       TYPE  2
TO DISPLAY LINK OCCUPANCY                                        TYPE  3
TO DISPLAY LINK OCCUPANCY BY DIRECTION AND PRIORITY              TYPE  4
TO DISPLAY ACCUMULATED TOTAL NETWORK STATISTICS                  TYPE  5
TO DISPLAY ACCUMULATED NETWORK PRECEDENCE STATISTICS             TYPE  6
TO DISPLAY ACCUMULATED SOURCE NODE NETWORK STATICS               TYPE  7
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE NETWORK
  STATISTICS                                                     TYPE  8
TO DISPLAY ACCUMULATED NODE-TO-NODE NETWORK STATISTICS           TYPE  9
0
```

```
                      *** USER STATISTICS ***

TO DISPLAY ACCUMULATED TOTAL NETWORK USER STATISTICS                TYPE  1
TO DISPLAY ACCUMULATED USER PRECEDENCE STATISTICS                   TYPE  2
TO DISPLAY ACCUMULATED SOURCE NODE USER STATISTICS                  TYPE  3
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE USER STATISTICS       TYPE  4
TO DISPLAY ACCUMULATED NODE-TO-NODE USER STATISTICS                 TYPE  5
1
```

```
                    ***** 0:30:59*****
         *ACCUMULATED TOTAL NETWORK USER STATISTICS*
     ATTEMPTS BLOCKS COMPLETE PREEMPTED BL/ATT PR/COM
         2322    188     2134       211 0.0810 0.0989
                    *** USER STATISTICS ***

TO DISPLAY ACCUMULATED TOTAL NETWORK USER STATISTICS                TYPE 1
TO DISPLAY ACCUMULATED USER PRECEDENCE STATISTICS                   TYPE 2
TO DISPLAY ACCUMULATED SOURCE NODE USER STATISTICS                  TYPE 3
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE USER STATISTICS       TYPE 4
TO DISPLAY ACCUMULATED NODE-TO-NODE USER STATISTICS                 TYPE 5
2
```

```
                    ***** 0:30:59*****
          *ACCUMULATED USER PRECEDENCE STATISTICS*
PREC ATTEMPTS BLOCKS COMPLETE PREEMPTED BL/ATT PR/COM PREC
   0        9      0        9         0 0.0000 0.0000    0
   1      197      0      197         0 0.0000 0.0000    1
   2      539     70      469        19 0.1299 0.0405    2
   3      642     38      604        57 0.0592 0.0944    3
   4      935     80      855       135 0.0856 0.1579    4
                 *** USER STATISTICS ***

TO DISPLAY ACCUMULATED TOTAL NETWORK USER STATISTICS           TYPE 1
TO DISPLAY ACCUMULATED USER PRECEDENCE STATISTICS              TYPE 2
TO DISPLAY ACCUMULATED SOURCE NODE USER STATISTICS             TYPE 3
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE USER STATISTICS  TYPE 4
TO DISPLAY ACCUMULATED NODE-TO-NODE USER STATISTICS            TYPE 5
3
```

***** 0:30:59*****

ACCUMULATED SOURCE NODE USER STATISTICS

NODE	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	NODE
1	198	42	156	42	0.2121	0.2692	1
2	124	4	120	9	0.0323	0.0750	2
3	208	21	187	25	0.1010	0.1337	3
4	249	14	235	9	0.0562	0.0383	4
5	81	6	75	5	0.0741	0.0667	5
6	177	17	160	9	0.0960	0.0562	6
7	74	1	73	3	0.0135	0.0411	7
8	174	18	156	19	0.1034	0.1218	8
9	79	3	76	2	0.0380	0.0263	9
10	67	8	59	0	0.1194	0.0000	10
11	76	5	71	6	0.0658	0.0845	11
12	184	10	174	15	0.0543	0.0862	12
13	63	14	49	3	0.2222	0.0612	13
14	106	9	97	15	0.0849	0.1546	14
15	61	5	56	5	0.0820	0.0893	15
16	121	3	118	12	0.0248	0.1017	16
17	140	2	138	9	0.0143	0.0652	17
18	140	6	134	23	0.0429	0.1716	18

*** USER STATISTICS ***

TO DISPLAY ACCUMULATED TOTAL NETWORK USER STATISTICS TYPE 1
TO DISPLAY ACCUMULATED USER PRECEDENCE STATISTICS TYPE 2
TO DISPLAY ACCUMULATED SOURCE NODE USER STATISTICS TYPE 3
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE USER STATISTICS TYPE 4
TO DISPLAY ACCUMULATED NODE-TO-NODE USER STATISTICS TYPE 5
4

***** 0:30:59*****

ACCUMULATED SOURCE NODE/PRECEDENCE USER STATISTICS

NODE	PREC	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	PREC	NODE
1	0	1	0	1	0	0.0000	0.0000	0	1
2	0	2	0	2	0	0.0000	0.0000	0	2
3	0	3	0	3	0	0.0000	0.0000	0	3
5	0	1	0	1	0	0.0000	0.0000	0	5
6	0	1	0	1	0	0.0000	0.0000	0	6
10	0	1	0	1	0	0.0000	0.0000	0	10
1	1	40	0	40	0	0.0000	0.0000	1	1
2	1	16	0	16	0	0.0000	0.0000	1	2
3	1	30	0	30	0	0.0000	0.0000	1	3
4	1	47	0	47	0	0.0000	0.0000	1	4
5	1	11	0	11	0	0.0000	0.0000	1	5
6	1	3	0	3	0	0.0000	0.0000	1	6
7	1	14	0	14	0	0.0000	0.0000	1	7
8	1	17	0	17	0	0.0000	0.0000	1	8
9	1	10	0	10	0	0.0000	0.0000	1	9
10	1	3	0	3	0	0.0000	0.0000	1	10
11	1	1	0	1	0	0.0000	0.0000	1	11
12	1	2	0	2	0	0.0000	0.0000	1	12
15	1	1	0	1	0	0.0000	0.0000	1	15
16	1	1	0	1	0	0.0000	0.0000	1	16
17	1	1	0	1	0	0.0000	0.0000	1	17
1	2	88	24	64	3	0.2727	0.0469	2	1
2	2	14	0	14	1	0.0000	0.0714	2	2
3	2	97	18	79	11	0.1856	0.1392	2	3
4	2	45	7	38	2	0.1556	0.0526	2	4
5	2	14	1	13	0	0.0714	0.0000	2	5
6	2	22	1	21	0	0.0455	0.0000	2	6
7	2	3	1	2					

				43	6	0.1064	0.1429	4	11
12	4	26	6	20	8	0.2308	0.4000	4	12
13	4	26	10	16	3	0.3846	0.1875	4	13
14	4	39	5	34	14	0.1282	0.4118	4	14
15	4	9	3	6	3	0.3333	0.5000	4	15
16	4	37	2	35	11	0.0541	0.3143	4	16
17	4	32	0	32	7	0.0000	0.2188	4	17
18	4	61	5	56	20	0.0820	0.3571	4	18

*** USER STATISTICS ***

```
TO DISPLAY ACCUMULATED TOTAL NETWORK USER STATISTICS               TYPE  1
TO DISPLAY ACCUMULATED USER PRECEDENCE STATISTICS                  TYPE  2
TO DISPLAY ACCUMULATED SOURCE NODE USER STATISTICS                 TYPE  3
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE USER STATISTICS      TYPE  4
TO DISPLAY ACCUMULATED NODE-TO-NODE USER STATISTICS                TYPE  5
5
```

***** 0:30:59*****

ACCUMULATED NODE TO NODE USER STATISTICS

NODE	NODE	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	NODE	NODE
2	1	17	0	17	1	0.0000	0.0588	2	1
3	1	111	20	91	24	0.1802	0.2637	3	1
4	1	55	12	43	8	0.2182	0.1860	4	1
5	1	21	3	18	4	0.1429	0.2222	5	1
6	1	13	6	7	1	0.4615	0.1429	6	1
7	1	11	1	10	1	0.0909	0.1000	7	1
8	1	69	16	53	13	0.2319	0.2453	8	1
9	1	10	2	8	1	0.2000	0.1250	9	1
10	1	12	6	6	0	0.5000	0.0000	10	1
11	1	7	0	7	1	0.0000	0.1429	11	1
1	2	13	2	11	2	0.1538	0.1818	1	2
3	2	3	0	3	0	0.0000	0.0000	3	2
4	2	9	0	9	0	0.0000	0.0000	4	2
5	2	6	0	6	0	0.0000	0.0000	5	2
6	2	37	0	37	0	0.0000	0.0000	6	2
7	2	2	0	2	0	0.0000	0.0000	7	2
8	2	5	0	5	3	0.0000	0.6000	8	2
9	2	5	0	5	0	0.0000	0.0000	9	2
1	3	31	8	23	7	0.2581	0.3043	1	3
2	3	32	3	29	6	0.0938	0.2069	2	3
4	3	71	1	70	0	0.0141	0.0000	4	3
5	3	6	0	6	0	0.0000	0.0000	5	3
6	3	29	2	27	3	0.0690	0.1111	6	3
7	3	30	0	30	0	0.0000	0.0000	7	3
8	3	42	1	41	1	0.0238	0.0244	8	3
9	3	18	0	18	0	0.0000	0.0000	9	3
10	3	17	0	17	0	0.0000	0.0000	10	3
11	3	28	2	26	3	0.0714	0.1154	11	3
1	4	43	7	36	11	0.1628	0.3056	1	4
2	4	16	0	16	0	0.0000	0.0000	2	4

			0	18	0	0.0000	0.0000	14	16
15	16	23	3	20	1	0.1304	0.0500	15	16
17	16	22	0	22	0	0.0000	0.0000	17	16
18	16	34	2	32	12	0.0588	0.3750	18	16
12	17	58	2	56	7	0.0345	0.1250	12	17
13	17	12	4	8	0	0.3333	0.0000	13	17
14	17	12	0	12	1	0.0000	0.0833	14	17
15	17	10	0	10	0	0.0000	0.0000	15	17
16	17	20	0	20	0	0.0000	0.0000	16	17
18	17	13	0	13	2	0.0000	0.1538	18	17
12	18	31	0	31	0	0.0000	0.0000	12	18
13	18	8	0	8	0	0.0000	0.0000	13	18
14	18	25	2	23	6	0.0800	0.2609	14	18
16	18	38	0	38	11	0.0000	0.2895	16	18
17	18	11	0	11	0	0.0000	0.0000	17	18

*** USER STATISTICS ***

TO DISPLAY ACCUMULATED TOTAL NETWORK USER STATISTICS TYPE 1
TO DISPLAY ACCUMULATED USER PRECEDENCE STATISTICS TYPE 2
TO DISPLAY ACCUMULATED SOURCE NODE USER STATISTICS TYPE 3
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE USER STATISTICS TYPE 4
TO DISPLAY ACCUMULATED NODE-TO-NODE USER STATISTICS TYPE 5

```
 *INPUT DATA*3
                    *** CONTROLLER INTERACTION MODE ***

TO DISPLAY NETWORK DIAGRAM                                       TYPE  1
TO INITIATE CONTROL ACTION                                       TYPE  2
TO DISPLAY NETWORK STATISTICS                                    TYPE  3
TO DISPLAY NETWORK STATUS                                        TYPE  4
TO RESET GOS DATA BASE                                           TYPE  5
TO DISPLAY ROUTING TABLE                                         TYPE  6
TO CLEAR TEKTRONIX SCREEN                                        TYPE  7
TO COPY TEKTRONIX SCREEN                                         TYPE  8
TO RETURN TO RUN OPTIONS                                        .TYPE  9
3
 *INPUT DATA*3
                         *** NETWORK STATISTICS ***

TO DISPLAY USER STATISTICS                                       TYPE  0
TO DISPLAY NODE OCCUPANCY                                        TYPE  1
TO DISPLAY NODE OCCUPANCY BY SOURCE-TANDEM/DESTINATION AND
  PRIORITY                                                       TYPE  2
TO DISPLAY LINK OCCUPANCY                                        TYPE  3
TO DISPLAY LINK OCCUPANCY BY DIRECTION AND PRIORITY              TYPE  4
TO DISPLAY ACCUMULATED TOTAL NETWORK STATISTICS                  TYPE  5
TO DISPLAY ACCUMULATED NETWORK PRECEDENCE STATISTICS             TYPE  6
TO DISPLAY ACCUMULATED SOURCE NODE NETWORK STATICS               TYPE  7
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE NETWORK
  STATISTICS                                                     TYPE  8
TO DISPLAY ACCUMULATED NODE-TO-NODE NETWORK STATISTICS           TYPE  9
1
```

```
                    ***** 0:36:16*****
              *NODE OCCUPANCY *  NODE:OCC/CAP
  1: 55/220     2: 61/428     3:101/604     4: 66/344     5: 50/388
  6: 37/216     7: 25/132     8: 85/548     9: 32/160    10: 14/128
 11: 23/ 96    12: 91/564    13: 33/216    14: 47/252    15: 17/ 80
 16: 42/240    17: 47/296    18: 45/264
                  *** NETWORK STATISTICS ***

TO DISPLAY USER STATISTICS                                         TYPE 0
TO DISPLAY NODE OCCUPANCY                                          TYPE 1
TO DISPLAY NODE OCCUPANCY BY SOURCE-TANDEM/DESTINATION AND
  PRIORITY                                                         TYPE 2
TO DISPLAY LINK OCCUPANCY                                          TYPE 3
TO DISPLAY LINK OCCUPANCY BY DIRECTION AND PRIORITY                TYPE 4
TO DISPLAY ACCUMULATED TOTAL NETWORK STATISTICS                    TYPE 5
TO DISPLAY ACCUMULATED NETWORK PRECEDENCE STATISTICS               TYPE 6
TO DISPLAY ACCUMULATED SOURCE NODE NETWORK STATICS                 TYPE 7
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE NETWORK
  STATISTICS                                                       TYPE 8
TO DISPLAY ACCUMULATED NODE-TO-NODE NETWORK STATISTICS             TYPE 9
```

```
                    ***** 0:36:42*****
        *NODE OCCUPANCY BY ORG-TANDEM/DEST AND' PRECEDENCE*
NODE=  1 TOT= 55 ORG= 16 T/D= 39  PO=  1  P1= 14  P2= 40  P3=  0  P4=  0
NODE=  2 TOT= 60 ORG= 21 T/D= 39  PO=  1  P1=  7  P2= 25  P3=  3  P4= 24
NODE=  3 TOT=100 ORG= 32 T/D= 68  PO=  1  P1= 18  P2= 26  P3= 18  P4= 37
NODE=  4 TOT= 68 ORG= 38 T/D= 30  PO=  1  P1=  8  P2=  8  P3= 11  P4= 40
NODE=  5 TOT= 50 ORG= 13 T/D= 37  PO=  2  P1=  7  P2= 11  P3=  6  P4= 24
NODE=  6 TOT= 36 ORG= 26 T/D= 10  PO=  0  P1=  0  P2=  6  P3=  7  P4= 23
NODE=  7 TOT= 29 ORG= 19 T/D= 10  PO=  2  P1=  1  P2=  1  P3=  8  P4= 17
NODE=  8 TOT= 86 ORG= 32 T/D= 54  PO=  0  P1= 15  P2= 13  P3= 13  P4= 45
NODE=  9 TOT= 33 ORG= 15 T/D= 18  PO=  1  P1=  3  P2=  4  P3=  3  P4= 22
NODE= 10 TOT= 15 ORG=  2 T/D= 13  PO=  0  P1=  4  P2=  1  P3=  1  P4=  9
NODE= 11 TOT= 23 ORG= 11 T/D= 12  PO=  1  P1=  1  P2=  3  P3=  4  P4= 14
NODE= 12 TOT= 88 ORG= 25 T/D= 63  PO=  0  P1=  1  P2= 29  P3= 46  P4= 12
NODE= 13 TOT= 33 ORG= 14 T/D= 19  PO=  0  P1=  0  P2=  8  P3= 18  P4=  7
NODE= 14 TOT= 45 ORG= 11 T/D= 34  PO=  0  P1=  1  P2= 16  P3= 18  P4= 10
NODE= 15 TOT= 17 ORG= 13 T/D=  4  PO=  0  P1=  1  P2=  3  P3= 10  P4=  3
NODE= 16 TOT= 43 ORG= 25 T/D= 18  PO=  0  P1=  1  P2=  8  P3= 19  P4= 15
NODE= 17 TOT= 48 ORG= 22 T/D= 26  PO=  0  P1=  1  P2= 11  P3= 27  P4=  9
NODE= 18 TOT= 44 ORG= 23 T/D= 21  PO=  0  P1=  0  P2=  6  P3= 25  P4= 13
                  *** NETWORK STATISTICS ***

TO DISPLAY USER STATISTICS                                      TYPE  0
TO DISPLAY NODE OCCUPANCY                                       TYPE  1
TO DISPLAY NODE OCCUPANCY BY SOURCE-TANDEM/DESTINATION AND
  PRIORITY                                                      TYPE  2
TO DISPLAY LINK OCCUPANCY                                       TYPE  3
TO DISPLAY LINK OCCUPANCY BY DIRECTION AND PRIORITY             TYPE  4
TO DISPLAY ACCUMULATED TOTAL NETWORK STATISTICS                 TYPE  5
TO DISPLAY ACCUMULATED NETWORK PRECEDENCE STATISTICS            TYPE  6
TO DISPLAY ACCUMULATED SOURCE NODE NETWORK STATICS              TYPE  7
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE NETWORK
  STATISTICS                                                    TYPE  8
TO DISPLAY ACCUMULATED NODE-TO-NODE NETWORK STATISTICS          TYPE  9
```

```
                  ***** 0:37  1*****
            *LINK OCCUPANCY *  LINK:OCC/CAP
  1: 22/ 22    2: 22/ 22    3: 11/ 11    4: 15/ 15    5: 13/ 14
  6:  6/  7    7: 21/ 34    8:  4/  5    9:  8/ 10   10: 17/ 30
 11: 14/ 20   12:  8/ 10   13: 10/ 13   14: 24/ 30   15:  2/ 11
 16:  5/  8   17: 31/ 34   18:  6/ 15   19: 15/ 18   20:  3/  9
 21: 17/ 17   22:  8/ 10   23: 12/ 12   24: 10/ 12   25:  8/ 12
 26:  6/  7   27: 30/ 54   28:  4/  5   29:  7/  7   30: 19/ 34
 31: 15/ 19   32: 12/ 12   33: 22/ 22   34: 11/ 12   35:  8/  8
 36:  8/  9   37:  9/ 12   38:  2/  6   39:  6/  8   40:  3/  3
 41: 18/ 28
               *** NETWORK STATISTICS ***

TO DISPLAY USER STATISTICS                                      TYPE 0
TO DISPLAY NODE OCCUPANCY                                       TYPE 1
TO DISPLAY NODE OCCUPANCY BY SOURCE-TANDEM/DESTINATION AND
  PRIORITY                                                      TYPE 2
TO DISPLAY LINK OCCUPANCY                                       TYPE 3
TO DISPLAY LINK OCCUPANCY BY DIRECTION AND PRIORITY             TYPE 4
TO DISPLAY ACCUMULATED TOTAL NETWORK STATISTICS                 TYPE 5
TO DISPLAY ACCUMULATED NETWORK PRECEDENCE STATISTICS            TYPE 6
TO DISPLAY ACCUMULATED SOURCE NODE NETWORK STATICS              TYPE 7
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE NETWORK
  STATISTICS                                                    TYPE 8
TO DISPLAY ACCUMULATED NODE-TO-NODE NETWORK STATISTICS          TYPE 9
4
```

```
                    ***** 0:37:18*****
          *LINK OCCUPANCY BY DIRECTION AND PRECEDENCE*
LINK=  1 TOT= 21 FOR=  3 REV= 18  P0=  0  P1=  3  P2= 18  P3=  0  P4=  0
LINK=  2 TOT= 22 FOR=  7 REV= 15  P0=  1  P1=  9  P2= 12  P3=  0  P4=  0
LINK=  3 TOT= 10 FOR=  5 REV=  5  P0=  0  P1=  3  P2=  7  P3=  0  P4=  0
LINK=  4 TOT= 15 FOR=  5 REV= 10  P0=  0  P1=  3  P2=  9  P3=  1  P4=  2
LINK=  5 TOT= 13 FOR=  6 REV=  7  P0=  0  P1=  0  P2=  4  P3=  1  P4=  8
LINK=  6 TOT=  6 FOR=  4 REV=  2  P0=  1  P1=  1  P2=  1  P3=  0  P4=  3
LINK=  7 TOT= 20 FOR= 10 REV= 10  P0=  0  P1=  0  P2=  2  P3=  2  P4= 16
LINK=  8 TOT=  4 FOR=  1 REV=  3  P0=  0  P1=  1  P2=  3  P3=  0  P4=  0
LINK=  9 TOT=  8 FOR=  4 REV=  4  P0=  0  P1=  1  P2=  4  P3=  0  P4=  3
LINK= 10 TOT= 15 FOR=  6 REV=  9  P0=  0  P1=  4  P2=  2  P3=  2  P4=  7
LINK= 11 TOT= 14 FOR=  8 REV=  6  P0=  0  P1=  1  P2=  3  P3=  4  P4=  6
LINK= 12 TOT=  8 FOR=  0 REV=  8  P0=  0  P1=  0  P2=  3  P3=  2  P4=  3
LINK= 13 TOT=  9 FOR=  1 REV=  8  P0=  1  P1=  1  P2=  0  P3=  3  P4=  4
LINK= 14 TOT= 27 FOR=  9 REV= 18  P0=  0  P1=  7  P2=  7  P3=  2  P4= 11
LINK= 15 TOT=  3 FOR=  1 REV=  2  P0=  0  P1=  0  P2=  1  P3=  0  P4=  2
LINK= 16 TOT=  6 FOR=  6 REV=  0  P0=  1  P1=  1  P2=  0  P3=  0  P4=  4
LINK= 17 TOT= 28 FOR= 14 REV= 14  P0=  0  P1=  3  P2=  2  P3=  5  P4= 18
LINK= 18 TOT=  6 FOR=  4 REV=  2  P0=  0  P1=  3  P2=  1  P3=  1  P4=  1
LINK= 19 TOT= 15 FOR=  9 REV=  6  P0=  1  P1=  2  P2=  1  P3=  2  P4=  9
LINK= 20 TOT=  2 FOR=  1 REV=  1  P0=  0  P1=  0  P2=  0  P3=  0  P4=  2
LINK= 21 TOT= 16 FOR=  8 REV=  8  P0=  1  P1=  1  P2=  3  P3=  3  P4=  8
LINK= 22 TOT=  7 FOR=  7 REV=  0  P0=  0  P1=  0  P2=  1  P3=  2  P4=  4
LINK= 23 TOT= 11 FOR=  7 REV=  4  P0=  0  P1=  0  P2=  0  P3=  3  P4=  8
LINK= 24 TOT=  9 FOR=  5 REV=  4  P0=  0  P1=  0  P2=  0  P3=  1  P4=  8
LINK= 25 TOT=  7 FOR=  7 REV=  0  P0=  0  P1=  3  P2=  0  P3=  1  P4=  3
LINK= 26 TOT=  7 FOR=  4 REV=  3  P0=  0  P1=  0  P2=  0  P3=  1  P4=  6
LINK= 27 TOT= 33 FOR= 15 REV= 18  P0=  0  P1=  0  P2=  4  P3= 20  P4=  9
LINK= 28 TOT=  5 FOR=  4 REV=  1  P0=  0  P1=  0  P2=  1  P3=  2  P4=  2
LINK= 29 TOT=  7 FOR=  6 REV=  1  P0=  0  P1=  0  P2=  1  P3=  4  P4=  2
LINK= 30 TOT= 20 FOR=  8 REV= 12  P0=  0  P1=  0  P2=  4  P3=  9  P4=  7
LINK= 31 TOT= 16 FOR=  7 REV=  9  P0=  0  P1=  1  P2=  8  P3=  7  P4=  0
LINK= 32 TOT= 12 FOR=  7 REV=  5  P0=  0  P1=  0  P2=  5  P3=  6  P4=  1
LINK= 33 TOT= 22 FOR=  6 REV= 16  P0=  0
```

```
                 ***** 0:37:40*****
          *ACCUMULATED TOTAL NETWORK STATISTICS*
       ATTEMPTS BLOCKS COMPLETE PREEMPTED BL/ATT PR/COM
         2815    242     2573       264 0.0860 0.1026
                 *** NETWORK STATISTICS ***

TO DISPLAY USER STATISTICS                                   TYPE  0
TO DISPLAY NODE OCCUPANCY                                    TYPE  1
TO DISPLAY NODE OCCUPANCY BY SOURCE-TANDEM/DESTINATION AND
  PRIORITY                                                   TYPE  2
TO DISPLAY LINK OCCUPANCY                                    TYPE  3
TO DISPLAY LINK OCCUPANCY BY DIRECTION AND PRIORITY          TYPE  4
TO DISPLAY ACCUMULATED TOTAL NETWORK STATISTICS              TYPE  5
TO DISPLAY ACCUMULATED NETWORK PRECEDENCE STATISTICS         TYPE  6
TO DISPLAY ACCUMULATED SOURCE NODE NETWORK STATICS           TYPE  7
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE NETWORK
  STATISTICS                                                 TYPE  8
TO DISPLAY ACCUMULATED NODE-TO-NODE NETWORK STATISTICS       TYPE  9
```

```
                    ***** 0:37:57*****
          *ACCUMULATED NETWORK PRECEDENCE STATISTICS*
  PREC ATTEMPTS BLOCKS COMPLETE PREEMPTED BL/ATT PR/COM PREC
     0       12      0       12         0 0.0000 0.0000    0
     1      239      0      239         0 0.0000 0.0000    1
     2      663     93      570        28 0.1403 0.0491    2
     3      779     48      731        71 0.0616 0.0971    3
     4     1137    101     1036       165 0.0888 0.1593    4
                  *** NETWORK STATISTICS ***

TO DISPLAY USER STATISTICS                                        TYPE  0
TO DISPLAY NODE OCCUPANCY                                         TYPE  1
TO DISPLAY NODE OCCUPANCY BY SOURCE-TANDEM/DESTINATION AND
  PRIORITY                                                        TYPE  2
TO DISPLAY LINK OCCUPANCY                                         TYPE  3
TO DISPLAY LINK OCCUPANCY BY DIRECTION AND PRIORITY               TYPE  4
TO DISPLAY ACCUMULATED TOTAL NETWORK STATISTICS                   TYPE  5
TO DISPLAY ACCUMULATED NETWORK PRECEDENCE STATISTICS              TYPE  6
TO DISPLAY ACCUMULATED SOURCE NODE NETWORK STATICS                TYPE  7
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE NETWORK
  STATISTICS                                                      TYPE  8
TO DISPLAY ACCUMULATED NODE-TO-NODE NETWORK STATISTICS            TYPE  9
```

***** 0:38:10*****

ACCUMULATED SOURCE NODE NETWORK STATISTICS

NODE	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	NODE
1	252	55	197	54	0.2183	0.2741	1
2	155	5	150	14	0.0323	0.0933	2
3	266	30	236	34	0.1128	0.1441	3
4	291	19	272	14	0.0653	0.0515	4
5	99	7	92	6	0.0707	0.0652	5
6	216	25	191	10	0.1157	0.0524	6
7	97	2	95	3	0.0206	0.0316	7
8	226	24	202	26	0.1062	0.1287	8
9	92	4	88	5	0.0435	0.0568	9
10	72	8	64	1	0.1111	0.0156	10
11	90	6	84	7	0.0667	0.0833	11
12	223	10	213	17	0.0448	0.0798	12
13	82	15	67	4	0.1829	0.0597	13
14	128	11	117	17	0.0859	0.1453	14
15	78	9	69	6	0.1154	0.0870	15
16	155	3	152	14	0.0194	0.0921	16
17	163	3	160	11	0.0184	0.0688	17
18	163	7	156	23	0.0429	0.1474	18

*** NETWORK STATISTICS ***

TO DISPLAY USER STATISTICS	TYPE 0
TO DISPLAY NODE OCCUPANCY	TYPE 1
TO DISPLAY NODE OCCUPANCY BY SOURCE-TANDEM/DESTINATION AND PRIORITY	TYPE 2
TO DISPLAY LINK OCCUPANCY	TYPE 3
TO DISPLAY LINK OCCUPANCY BY DIRECTION AND PRIORITY	TYPE 4
TO DISPLAY ACCUMULATED TOTAL NETWORK STATISTICS	TYPE 5
TO DISPLAY ACCUMULATED NETWORK PRECEDENCE STATISTICS	TYPE 6
TO DISPLAY ACCUMULATED SOURCE NODE NETWORK STATICS	TYPE 7
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE NETWORK STATISTICS	TYPE 8
TO DISPLAY ACCUMULATED NODE-TO-NODE NETWORK STATISTICS	TYPE 9

***** 0:38:31*****

ACCUMULATED SOURCE NODE/PRECEDENCE NETWORK STATISTICS

NODE	PREC	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	PREC	NODE
1	0	1	0	1	0	0.0000	0.0000	0	1
2	0	2	0	2	0	0.0000	0.0000	0	2
3	0	3	0	3	0	0.0000	0.0000	0	3
4	0	1	0	1	0	0.0000	0.0000	0	4
5	0	1	0	1	0	0.0000	0.0000	0	5
6	0	1	0	1	0	0.0000	0.0000	0	6
7	0	1	0	1	0	0.0000	0.0000	0	7
10	0	1	0	1	0	0.0000	0.0000	0	10
11	0	1	0	1	0	0.0000	0.0000	0	11
1	1	57	0	57	0	0.0000	0.0000	1	1
2	1	19	0	19	0	0.0000	0.0000	1	2
3	1	40	0	40	0	0.0000	0.0000	1	3
4	1	52	0	52	0	0.0000	0.0000	1	4
5	1	12	0	12	0	0.0000	0.0000	1	5
6	1	3	0	3	0	0.0000	0.0000	1	6
7	1	15	0	15	0	0.0000	0.0000	1	7
8	1	25	0	25	0	0.0000	0.0000	1	8
9	1	10	0	10	0	0.0000	0.0000	1	9
10	1	3	0	3	0	0.0000	0.0000	1	10
11	1	1	0	1	0	0.0000	0.0000	1	11
12	1	2	0	2	0	0.0000	0.0000	1	12
15	1	1	0	1	0	0.0000	0.0000	1	15
16	1	2	0	2	0	0.0000	0.0000	1	16
17	1	1	0	1	0	0.0000	0.0000	1	17
1	2	109	29	80	6	0.2661	0.0750	2	1
2	2	17	1	16	1	0.0588	0.0625	2	2
3	2	125	27	98	15	0.2160	0.1531	2	3
4	2	56	10	46	2	0.1786	0.0435	2	4
5	2	16	2	14	0	0.1250	0.0000	2	5
6	2	27	2	25	0	0.0741	0.0000	2	6
7	2	6	2	4	0	0.3333	0.0000	2	7
8	2	68	14						

	4	49	3	46	0	0.0612	0.0000	4	10
11	4	55	6	49	6	0.1091	0.1224	4	11
12	4	30	6	24	10	0.2000	0.4167	4	12
13	4	34	10	24	4	0.2941	0.1667	4	13
14	4	44	7	37	16	0.1591	0.4324	4	14
15	4	14	5	9	5	0.3571	0.5556	4	15
16	4	53	2	51	13	0.0377	0.2549	4	16
17	4	37	1	36	9	0.0270	0.2500	4	17
18	4	68	6	62	20	0.0882	0.3226	4	18

*** NETWORK STATISTICS ***

```
TO DISPLAY USER STATISTICS                                     TYPE  0
TO DISPLAY NODE OCCUPANCY                                      TYPE  1
TO DISPLAY NODE OCCUPANCY BY SOURCE-TANDEM/DESTINATION AND
  PRIORITY                                                     TYPE  2
TO DISPLAY LINK OCCUPANCY                                      TYPE  3
TO DISPLAY LINK OCCUPANCY BY DIRECTION AND PRIORITY            TYPE  4
TO DISPLAY ACCUMULATED TOTAL NETWORK STATISTICS                TYPE  5
TO DISPLAY ACCUMULATED NETWORK PRECEDENCE STATISTICS           TYPE  6
TO DISPLAY ACCUMULATED SOURCE NODE NETWORK STATICS             TYPE  7
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE NETWORK
  STATISTICS                                                   TYPE  8
TO DISPLAY ACCUMULATED NODE-TO-NODE NETWORK STATISTICS         TYPE  9
```

***** 0:39: 0*****

ACCUMULATED NODE TO NODE NETWORK STATISTICS

NODE	NODE	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	NODE	NODE
2	1	20	1	19	1	0.0500	0.0526	2	1
3	1	145	29	116	33	0.2000	0.2845	3	1
4	1	69	16	53	13	0.2319	0.2453	4	1
5	1	23	4	19	4	0.1739	0.2105	5	1
6	1	19	8	11	1	0.4211	0.0909	6	1
7	1	16	2	14	1	0.1250	0.0714	7	1
8	1	94	22	72	17	0.2340	0.2361	8	1
9	1	13	3	10	2	0.2308	0.2000	9	1
10	1	14	6	8	1	0.4286	0.1250	10	1
11	1	9	0	9	2	0.0000	0.2222	11	1
1	2	18	4	14	2	0.2222	0.1429	1	2
3	2	6	0	6	0	0.0000	0.0000	3	2
4	2	13	0	13	0	0.0000	0.0000	4	2
5	2	7	0	7	0	0.0000	0.0000	5	2
6	2	46	0	46	0	0.0000	0.0000	6	2
7	2	2	0	2	0	0.0000	0.0000	7	2
8	2	6	0	6	3	0.0000	0.5000	8	2
9	2	6	0	6	0	0.0000	0.0000	9	2
1	3	40	11	29	10	0.2750	0.3448	1	3
2	3	36	3	33	7	0.0833	0.2121	2	3
4	3	81	1	80	0	0.0123	0.0000	4	3
5	3	10	0	10	0	0.0000	0.0000	5	3
6	3	35	4	31	3	0.1143	0.0968	6	3
7	3	42	0	42	0	0.0000	0.0000	7	3
8	3	58	1	57	2	0.0172	0.0351	8	3
9	3	20	0	20	0	0.0000	0.0000	9	3
10	3	18	0	18	0	0.0000	0.0000	10	3
11	3	31	2	29	3	0.0645	0.1034	11	3
1	4	48	8	40	13	0.1667	0.3250	1	4
2	4	20	0	20	0	0.0000	0.0000	2	4
3	4	35	0	35	0	0.0000	0.0000	3	4
5	4	3	0						

							0.1704	12	16
13	16	8	0	8	0	0.0000	0.0000	13	16
14	16	20	0	20	0	0.0000	0.0000	14	16
15	16	26	4	22	1	0.1538	0.0455	15	16
17	16	24	0	24	0	0.0000	0.0000	17	16
18	16	47	3	44	12	0.0638	0.2727	18	16
12	17	67	2	65	8	0.0299	0.1231	12	17
13	17	15	5	10	0	0.3333	0.0000	13	17
14	17	13	0	13	1	0.0000	0.0769	14	17
15	17	11	0	11	0	0.0000	0.0000	15	17
16	17	24	0	24	0	0.0000	0.0000	16	17
18	17	14	0	14	2	0.0000	0.1429	18	17
12	18	43	0	43	0	0.0000	0.0000	12	18
13	18	16	0	16	0	0.0000	0.0000	13	18
14	18	33	2	31	7	0.0606	0.2258	14	18
15	18	1	0	1	0	0.0000	0.0000	15	18
16	18	50	0	50	12	0.0000	0.2400	16	18
17	18	12	0	12	0	0.0000	0.0000	17	18

*** NETWORK STATISTICS ***

```
TO DISPLAY USER STATISTICS                                        TYPE 0
TO DISPLAY NODE OCCUPANCY                                         TYPE 1
TO DISPLAY NODE OCCUPANCY BY SOURCE-TANDEM/DESTINATION AND
  PRIORITY                                                        TYPE 2
TO DISPLAY LINK OCCUPANCY                                         TYPE 3
TO DISPLAY LINK OCCUPANCY BY DIRECTION AND PRIORITY               TYPE 4
TO DISPLAY ACCUMULATED TOTAL NETWORK STATISTICS                   TYPE 5
TO DISPLAY ACCUMULATED NETWORK PRECEDENCE STATISTICS              TYPE 6
TO DISPLAY ACCUMULATED SOURCE NODE NETWORK STATICS                TYPE 7
TO DISPLAY ACCUMULATED SOURCE NODE/PRECEDENCE NETWORK
  STATISTICS                                                      TYPE 8
TO DISPLAY ACCUMULATED NODE-TO-NODE NETWORK STATISTICS            TYPE 9
```

```
                    *** CONTROLLER INTERACTION MODE ***

TO DISPLAY NETWORK DIAGRAM                                      TYPE  1
TO INITIATE CONTROL ACTION                                      TYPE  2
TO DISPLAY NETWORK STATISTICS                                   TYPE  3
TO DISPLAY NETWORK STATUS                                       TYPE  4
TO RESET GOS DATA BASE                                          TYPE  5
TO DISPLAY ROUTING TABLE                                        TYPE  6
TO CLEAR TEKTRONIX SCREEN                                       TYPE  7
TO COPY TEKTRONIX SCREEN                                        TYPE  8
TO RETURN TO RUN OPTIONS                                        TYPE  9
4
                         *** NETWORK STATUS ***

TO DISPLAY ACCUMULATED NODE/PRIORITY PREEMPTION STATUS          TYPE  1
TO DISPLAY ACCUMULATED NODE/PRIORITY GOS STATUS                 TYPE  2
TO DISPLAY ACCUMULATED LINK/PRIORITY PREEMPTION STATUS          TYPE  3
TO DISPLAY ACCUMULATED LINK PRIORITY GOS STATUS                 TYPE  4
```

```
                         ***** 0:53:15*****
              *ACCUMULATED NODE/PRIORITY PREEMPTION STATUS*
NODE A       TOTAL           P0          P1          P2          P3          P4
        PREM/COMP=X.XX PREM/COMP PREM/COMP PREM/COMP PREM/COMP PREM/COMP
    1     0/ 715=0.00    0/   4    0/ 131    0/ 387    0/ 117    0/  76
    2     0/ 855=0.00    0/   3    0/ 119    0/ 321    0/ 129    0/ 283
    3     0/1328=0.00    0/   8    0/ 179    0/ 446    0/ 223    0/ 472
    4     0/ 746=0.00    0/   3    0/ 102    0/ 140    0/ 109    0/ 392
    5     0/ 644=0.00    0/   6    0/  73    0/ 267    0/  91    0/ 207
    6     0/ 414=0.00    0/   1    0/  17    0/  58    0/  58    0/ 280
    7     0/ 226=0.00    0/   2    0/  38    0/  13    0/  37    0/ 136
    8     0/ 912=0.00    0/   4    0/ 125    0/ 166    0/ 142    0/ 475
    9     0/ 285=0.00    0/   2    0/  55    0/  35    0/  31    0/ 162
   10     0/ 184=0.00    0/   3    0/  12    0/  28    0/  23    0/ 118
   11     0/ 188=0.00    0/   2    0/   3    0/  23    0/  27    0/ 133
   12     0/ 873=0.00    0/   0    0/   9    0/ 252    0/ 413    0/ 199
   13     0/ 332=0.00    0/   0    0/   2    0/  69    0/ 158    0/ 103
   14     0/ 496=0.00    0/   0    0/   2    0/ 111    0/ 243    0/ 140
   15     0/ 180=0.00    0/   0    0/   3    0/  33    0/  98    0/  46
   16     0/ 424=0.00    0/   0    0/   2    0/  75    0/ 221    0/ 126
   17     0/ 552=0.00    0/   0    0/   6    0/ 124    0/ 264    0/ 158
   18     0/ 404=0.00    0/   0    0/   1    0/  66    0/ 176    0/ 161
                        *** NETWORK STATUS ***

TO DISPLAY ACCUMULATED NODE/PRIORITY PREEMPTION STATUS          TYPE 1
TO DISPLAY ACCUMULATED NODE/PRIORITY GOS STATUS                 TYPE 2
TO DISPLAY ACCUMULATED LINK/PRIORITY PREEMPTION STATUS          TYPE 3
TO DISPLAY ACCUMULATED LINK PRIORITY GOS STATUS                 TYPE 4
```

```
                   ***** 0:53:33*****
          *ACCUMULATED NODE/PRIORITY GOS STATUS
NODE A       TOTAL          P0          P1          P2          P3          P4
       BLCK/ATTM=X.XX BLCK/ATTM BLCK/ATTM BLCK/ATTM BLCK/ATTM BLCK/ATTM
  1      0/ 719=0.00    0/   4    0/ 131    0/ 391    0/ 117    0/  76
  2      0/ 858=0.00    0/   3    0/ 119    0/ 323    0/ 129    0/ 284
  3      0/1335=0.00    0/   8    0/ 180    0/ 449    0/ 226    0/ 472
  4      0/ 748=0.00    0/   3    0/ 103    0/ 140    0/ 110    0/ 392
  5      0/ 647=0.00    0/   6    0/  73    0/ 268    0/  92    0/ 208
  6      0/ 416=0.00    0/   1    0/  17    0/  58    0/  59    0/ 281
  7      0/ 226=0.00    0/   2    0/  38    0/  13    0/  37    0/ 136
  8      0/ 915=0.00    0/   4    0/ 126    0/ 167    0/ 143    0/ 475
  9      0/ 285=0.00    0/   2    0/  55    0/  35    0/  31    0/ 162
 10      0/ 185=0.00    0/   3    0/  12    0/  29    0/  23    0/ 118
 11      0/ 191=0.00    0/   2    0/   3    0/  24    0/  28    0/ 134
 12      0/ 879=0.00    0/   0    0/   9    0/ 254    0/ 416    0/ 200
 13      0/ 336=0.00    0/   0    0/   2    0/  70    0/ 160    0/ 104
 14      0/ 500=0.00    0/   0    0/   2    0/ 113    0/ 245    0/ 140
 15      0/ 182=0.00    0/   0    0/   3    0/  34    0/  99    0/  46
 16      0/ 426=0.00    0/   0    0/   2    0/  76    0/ 222    0/ 126
 17      0/ 555=0.00    0/   0    0/   6    0/ 126    0/ 265    0/ 158
 18      0/ 408=0.00    0/   0    0/   1    0/  66    0/ 179    0/ 162
                   *** NETWORK STATUS ***

TO DISPLAY ACCUMULATED NODE/PRIORITY PREEMPTION STATUS          TYPE 1
TO DISPLAY ACCUMULATED NODE/PRIORITY GOS STATUS                 TYPE 2
TO DISPLAY ACCUMULATED LINK/PRIORITY PREEMPTION STATUS          TYPE 3
TO DISPLAY ACCUMULATED LINK PRIORITY GOS STATUS                 TYPE 4
3
```

***** 0:53:51*****

ACCUMULATED LINK/PRIORITY PREEMPTION STATUS

LINK	A	TOTAL	P0	P1	P2	P3	P4
		PREM/COMP=X.XX	PREM/COMP	PREM/COMP	PREM/COMP	PREM/COMP	PREM/COMP
1		44/ 221=0.20	0/ 1	0/ 53	5/ 116	23/ 30	16/ 21
2		75/ 292=0.26	0/ 3	0/ 41	21/ 173	34/ 48	20/ 27
3	*	38/ 106=0.36	0/ 0	0/ 14	9/ 62	15/ 15	14/ 15
4		2/ 236=0.01	0/ 1	0/ 43	0/ 119	0/ 32	2/ 41
5		3/ 171=0.02	0/ 0	0/ 22	0/ 54	0/ 25	3/ 70
6		1/ 67=0.01	0/ 1	0/ 12	0/ 29	0/ 8	1/ 17
7		2/ 248=0.01	0/ 0	0/ 12	0/ 54	0/ 32	2/ 150
8		8/ 105=0.08	0/ 0	0/ 9	0/ 51	1/ 28	7/ 17
9		3/ 81=0.04	0/ 0	0/ 15	0/ 17	0/ 9	3/ 40
10		4/ 348=0.01	0/ 1	0/ 43	0/ 115	0/ 56	4/ 133
11		0/ 220=0.00	0/ 0	0/ 20	0/ 110	0/ 30	0/ 60
12		2/ 89=0.02	0/ 0	0/ 1	0/ 13	0/ 12	2/ 63
13		0/ 100=0.00	0/ 1	0/ 14	0/ 10	0/ 17	0/ 58
14		24/ 394=0.06	0/ 2	0/ 65	0/ 133	0/ 70	24/ 124
15		0/ 63=0.00	0/ 2	0/ 6	0/ 17	0/ 10	0/ 28
16		0/ 54=0.00	0/ 1	0/ 18	0/ 2	0/ 6	0/ 27
17		1/ 308=0.00	0/ 1	0/ 42	0/ 32	0/ 38	1/ 195
18		0/ 158=0.00	0/ 1	0/ 13	0/ 85	0/ 32	0/ 27
19		1/ 124=0.01	0/ 2	0/ 32	0/ 15	0/ 14	1/ 61
20		1/ 93=0.01	0/ 4	0/ 7	0/ 22	0/ 15	1/ 45
21		5/ 124=0.04	0/ 0	0/ 2	0/ 20	0/ 15	5/ 87
22		7/ 87=0.08	0/ 1	0/ 6	0/ 10	0/ 13	7/ 57
23		1/ 81=0.01	0/ 0	0/ 8	0/ 4	0/ 16	1/ 53
24		2/ 102=0.02	0/ 0	0/ 13	0/ 6	0/ 13	2/ 70
25		0/ 74=0.00	0/ 0	0/ 5	0/ 6	0/ 10	0/ 53
26		0/ 62=0.00	0/ 0	0/ 2	0/ 6	0/ 13	0/ 41
27		0/ 318=0.00	0/ 0	0/ 1	0/ 58	0/ 143	0/ 116
28		4/ 45=0.09	0/ 0	0/ 0	0/ 7	0/ 20	4/ 18
29		0/ 49=0.00	0/ 0	0/ 0	0/ 2	0/ 17	0/ 30
30		0/ 248=0.00	0/ 0	0/			

***** 0:54:12*****
*ACCUMULATED LINK/PRIORITY GOS STATUS

LINK A	TOTAL BLCK/ATTM=X.XX	P0 BLCK/ATTM	P1 BLCK/ATTM	P2 BLCK/ATTM	P3 BLCK/ATTM	P4 BLCK/ATTM
1**	435/ 658=0.66	1/ 2	57/ 110	262/ 379	90/ 120	25/ 47
2**	626/ 919=0.68	2/ 5	94/ 135	378/ 551	108/ 156	44/ 72
3***	437/ 544=0.80	6/ 6	55/ 69	262/ 325	88/ 103	26/ 41
4	12/ 249=0.05	0/ 1	1/ 44	6/ 125	3/ 35	2/ 44
5	22/ 194=0.11	0/ 0	2/ 24	9/ 63	5/ 30	6/ 77
6	18/ 85=0.21	0/ 1	4/ 16	10/ 39	2/ 10	2/ 19
7	5/ 254=0.02	0/ 0	2/ 14	0/ 54	2/ 35	1/ 151
8 *	61/ 167=0.37	0/ 0	6/ 15	42/ 94	7/ 35	6/ 23
9	15/ 96=0.16	0/ 0	3/ 18	8/ 25	0/ 9	4/ 44
10	24/ 372=0.06	0/ 1	2/ 45	9/ 124	5/ 61	8/ 141
11	0/ 221=0.00	0/ 0	0/ 20	0/ 110	0/ 30	0/ 61
12	36/ 125=0.29	0/ 0	0/ 1	5/ 18	11/ 23	20/ 83
13	3/ 103=0.03	0/ 1	0/ 14	0/ 10	1/ 18	2/ 60
14	117/ 513=0.23	2/ 4	21/ 86	34/ 169	20/ 90	40/ 164
15	0/ 63=0.00	0/ 2	0/ 6	0/ 17	0/ 10	0/ 28
16	7/ 61=0.11	0/ 1	2/ 20	0/ 2	2/ 8	3/ 30
17	9/ 321=0.03	1/ 2	0/ 42	0/ 32	3/ 43	5/ 202
18	0/ 159=0.00	0/ 1	0/ 13	0/ 86	0/ 32	0/ 27
19	17/ 141=0.12	0/ 2	3/ 35	5/ 20	1/ 15	8/ 69
20	3/ 96=0.03	0/ 4	0/ 7	2/ 24	0/ 15	1/ 46
21	30/ 154=0.19	4/ 4	0/ 2	5/ 25	2/ 17	19/ 106
22**	119/ 206=0.58	0/ 1	6/ 12	5/ 15	21/ 34	87/ 144
23	7/ 88=0.08	0/ 0	0/ 8	1/ 5	2/ 18	4/ 57
24	23/ 126=0.18	0/ 0	5/ 18	4/ 10	1/ 14	13/ 84
25	0/ 74=0.00	0/ 0	0/ 5	0/ 6	0/ 10	0/ 53
26	26/ 88=0.30	0/ 0	0/ 2	2/ 8	3/ 16	21/ 62
27	0/ 320=0.00	0/ 0	0/ 1	0/ 59	0/ 143	0/ 117
28**	60/ 106=0.57	0/ 0	0/ 0	11/ 19	26/ 46	23/ 41
29 *	29/ 79=0.37	0/ 0	0/ 0	1/ 3	11/ 28	17/ 48
30	0/ 248=0.00	0/ 0	0/ 2	0/ 61	0/ 1	

```
 *INPUT DATA*3
                    *** CONTROLLER INTERACTION MODE ***

TO DISPLAY NETWORK DIAGRAM                                          TYPE  1
TO INITIATE CONTROL ACTION                                          TYPE  2
TO DISPLAY NETWORK STATISTICS                                       TYPE  3
TO DISPLAY NETWORK STATUS                                           TYPE  4
TO RESET GOS DATA BASE                                              TYPE  5
TO DISPLAY ROUTING TABLE                                            TYPE  6
TO CLEAR TEKTRONIX SCREEN                                           TYPE  7
TO COPY TEKTRONIX SCREEN                                            TYPE  8
TO RETURN TO RUN OPTIONS                                            TYPE  9
6
 *INPUT DATA*6
                          *** ROUTING TABLE ***

TO DISPLAY NODE-TO NODE ROUTING TABLE                               TYPE  1
TO DISPLAY SOURCE/DESTINATION/TANDEM ROUTING TABLE                  TYPE  2
TO DISPLAY NODE-TO-NODE EXPANDED ROUTING TABLE                      TYPE  3
1
```

***** 0:30:59*****

NODE TO NODE ROUTING TABLE

NS	PTH	ND1S	ND2S	ND3S	ND4S	ND5S
1	1	0:0	2:1	3:1	3:0	5:1
	2	0:0	3:0	2:0	2:0	3:0
	3	0:0	5:0	5:0	5:0	2:0
	4	0:0	0:0	0:0	0:0	0:0
2	1	1:1	0:0	3:1	4:1	5:1
	2	3:1	0:0	6:1	3:1	3:1
	3	5:1	0:0	0:0	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0
3	1	1:1	2:1	0:0	4:1	5:1
	2	2:1	6:1	0:0	8:1	8:1
	3	5:1	0:0	0:0	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0
4	1	3:1	2:1	3:1	0:0	8:1
	2	2:1	3:1	8:1	0:0	3:1
	3	0:0	0:0	0:0	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0
5	1	1:1	2:1	3:1	8:1	0:0
	2	3:1	3:1	8:1	3:1	0:0
	3	2:1	0:0	0:0	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0

*** ROUTING TABLE ***

TO DISPLAY NODE-TO NODE ROUTING TABLE TYPE 1
TO DISPLAY SOURCE/DESTINATION/TANDEM ROUTING TABLE TYPE 2
TO DISPLAY NODE-TO-NODE EXPANDED ROUTING TABLE TYPE 3

***** 0:30:59*****

*ROUTING TABLE FOR NODES *NS* TO *ND* WITH TANDEM PATH NODES *NTI**
*AND SPILL INDICATORS *SI* FOR PATHS *I**

NS	ND	NT1:S	NT2:S	NT3:S	NT4:S
1	2	2:1	3:0	5:0	
1	3	3:1	2:0	5:0	
1	4	3:0	2:0	5:0	
1	5	5:1	3:0	2:0	
2	1	1:1	3:1	5:1	
2	3	3:1	6:1		
2	4	4:1	3:1		
2	5	5:1	3:1		
3	1	1:1	2:1	5:1	
3	2	2:1	6:1		
3	4	4:1	8:1		
3	5	5:1	8:1		
4	1	3:1	2:1		
4	2	2:1	3:1		
4	3	3:1	8:1		
4	5	8:1	3:1		
5	1	1:1	3:1	2:1	
5	2	2:1	3:1		
5	3	3:1	8:1		
5	4	8:1	3:1		

*** ROUTING TABLE ***

TO DISPLAY NODE-TO NODE ROUTING TABLE TYPE 1
TO DISPLAY SOURCE/DESTINATION/TANDEM ROUTING TABLE TYPE 2
TO DISPLAY NODE-TO-NODE EXPANDED ROUTING TABLE TYPE 3

```
                              *** RUN OPTIONS ***

TO START NORMAL RUN                                                     TYPE  1
TO TERMINATE RUN AND REEXECUTE                                          TYPE  2
TO INITIATE CONTROLLER INTERACTION                                      TYPE  3
TO INITIATE NETWORK PERTURBATION                                        TYPE  4
TO CHANGE PROGRAM TIME SCALE                                            TYPE  5
TO PARTIALLY INITIALIZE NETWORK AND ENVIRONMENT AND THEN RUN            TYPE  6
TO ABORT PROGRAM EXECUTION                                              TYPE  9
4
 *INPUT DATA*4
* INITIATE PERTURBATION *
 ENTER NEGATIVE NUMBER TO QUEUE AND POSITIVE NUMBER TO IMPLEMENT THIS AND
 OTHER QUEUED PERTURBATIONS
 TO RESET ALL PERTURBATIONS                               TYPE  1 OR  -1
 TO REMOVE LINKS                                          TYPE  2 OR  -2
 TO RESTORE LINKS                                         TYPE  3 OR  -3
 TO REMOVE NODES                                          TYPE  4 OR  -4
 TO RESTORE NODES                                         TYPE  5 OR  -5
 TO CHANGE LINK CAPACITIES                                TYPE  6 OR  -6
 TO CHANGE NODE CAPACITIES                                TYPE  7 OR  -7
 TO CHANGE TRAFFIC LOADS                                  TYPE  8 OR  -8
 TO IMPLEMENT QUEUED PERTURBATIONS                        TYPE       -99
 TO DELETE QUEUE                                          TYPE 99
 TO TERMINATE DATA INPUT                                  TYPE A BLANK
ENTER PERTURBATION OPTION
2
 *INPUT DATA*2
 * LINK DESTRUCTION: TYPE IN LINKS AS XX,XX,....

 *INPUT DATA*
                             ***** 0:30:59*****
ENTER PERTURBATION OPTION
4
```

```
                        *** RUN OPTIONS ***
TO START NORMAL RUN                                              TYPE  1
TO TERMINATE RUN AND REEXECUTE                                   TYPE  2
TO INITIATE CONTROLLER INTERACTION                               TYPE  3
TO INITIATE NETWORK PERTURBATION                                 TYPE  4
TO CHANGE PROGRAM TIME SCALE                                     TYPE  5
TO PARTIALLY INITIALIZE NETWORK AND ENVIRONMENT AND THEN RUN     TYPE  6
TO ABORT PROGRAM EXECUTION                                       TYPE  9
4
* INITIATE PERTURBATION *
 ENTER NEGATIVE NUMBER TO QUEUE AND POSITIVE NUMBER TO IMPLEMENT THIS AND
 OTHER QUEUED PERTURBATIONS
 TO RESET ALL PERTURBATIONS                   TYPE  1 OR  -1
 TO REMOVE LINKS                              TYPE  2 OR  -2
 TO RESTORE LINKS                             TYPE  3 OR  -3
 TO REMOVE NODES                              TYPE  4 OR  -4
 TO RESTORE NODES                             TYPE  5 OR  -5
 TO CHANGE LINK CAPACITIES                    TYPE  6 OR  -6
 TO CHANGE NODE CAPACITIES                    TYPE  7 OR  -7
 TO CHANGE TRAFFIC LOADS                      TYPE  8 OR  -8
 TO IMPLEMENT QUEUED PERTURBATIONS            TYPE       -99
 TO DELETE QUEUE                              TYPE 99
 TO TERMINATE DATA INPUT                      TYPE A BLANK
ENTER PERTURBATION OPTION
2
 * LINK DESTRUCTION: TYPE IN LINKS AS XX,XX,....
10,
 * LINK DESTRUCTION: TYPE IN LINKS AS XX,XX,....

 * LINK DESTRUCT: LINKS=  10

ENTER PERTURBATION OPTION
4
```

```
1,
 * NODE DESTRUCTION: TYPE IN NODES AS XX,XX,....

 * NODE DESTRUCT: NODES=   1

ENTER PERTURBATION OPTION
3
 * LINK RESTORAL: TYPE IN LINKS AS XX,XX,....
10,
 * LINK RESTORAL: TYPE IN LINKS AS XX,XX,....

 * LINK RESTORAL: LINKS=  10

ENTER PERTURBATION OPTION
5
 * NODE RESTORAL: TYPE IN NODES AS XX,XX,....
1,
 * NODE RESTORAL: TYPE IN NODES AS XX,XX,....

 * NODE RESTORAL: NODES=   1

ENTER PERTURBATION OPTION
6
 * LINK CAPACITY CHANGE: TYPE IN  LINK,CAP,  ON EACH LINE, TERMINATING
   WITH <RETURN> OR TYPE AS LINK,CAP,LINK,CAP,...,-1,
   WHERE EITHER A  -1 OR TWO <RETURN>S TERMINATES
1,30,
 * LINK CAPACITY CHANGE: TYPE IN  LINK,CAP,  ON EACH LINE, TERMINATING
   WITH <RETURN> OR TYPE AS LINK,CAP,LINK,CAP,...,-1,
   WHERE EITHER A  -1 OR TWO <RETURN>S TERMINATES

 * LINK CAPACITY CHANGE:  LINK=  1  OLD CAP= 22  NEW CAP = 30*
ENTER PERTURBATION OPTION
```

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HYBRID COMPUTER SIMULATION STUDIES FOR SYSTEM CONTROL AND TRANS--ETC(U)
JUN 78 DCA100-77-C-0061
UNCLASSIFIED OR-15119 SBIE -AD-E100 238 NL

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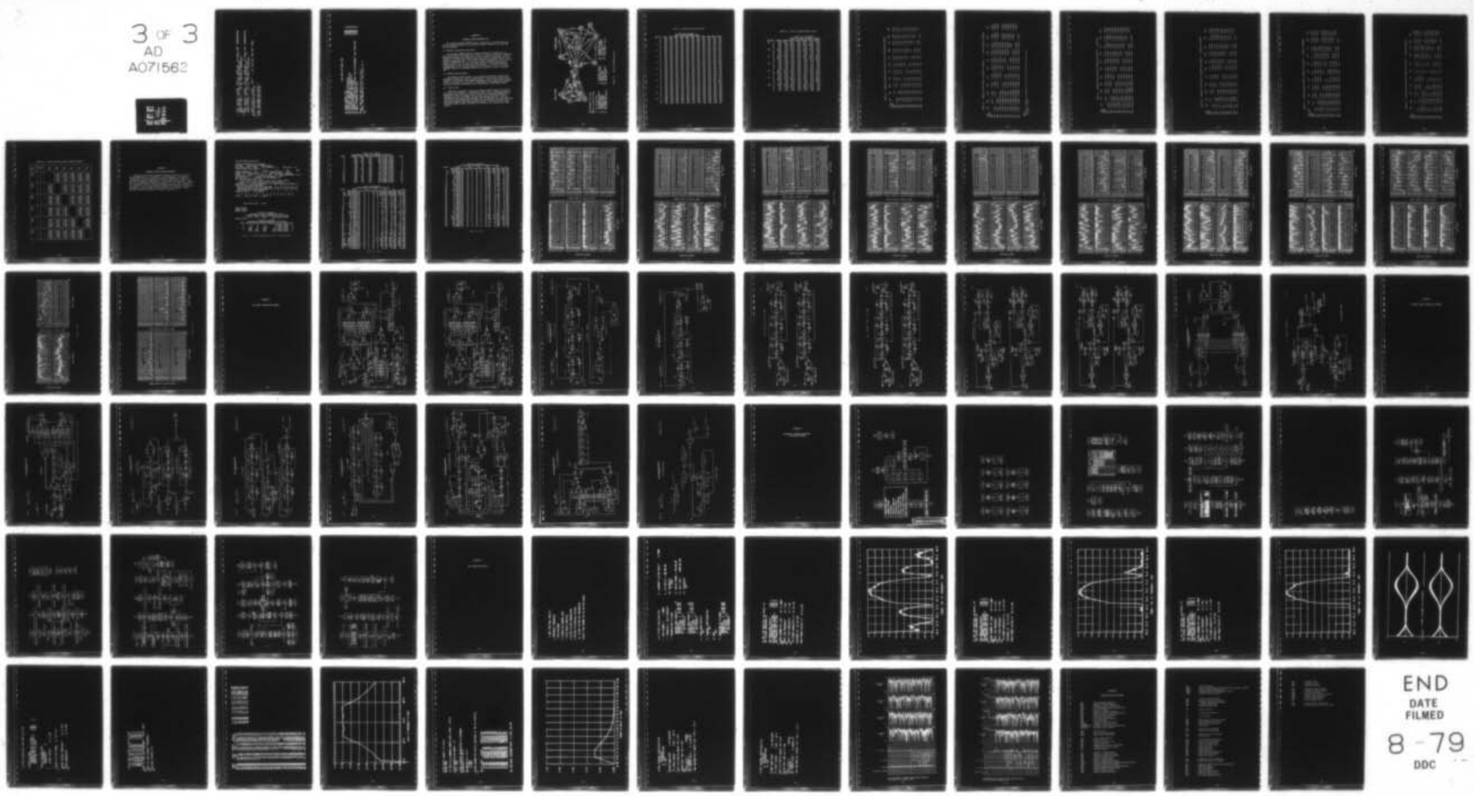

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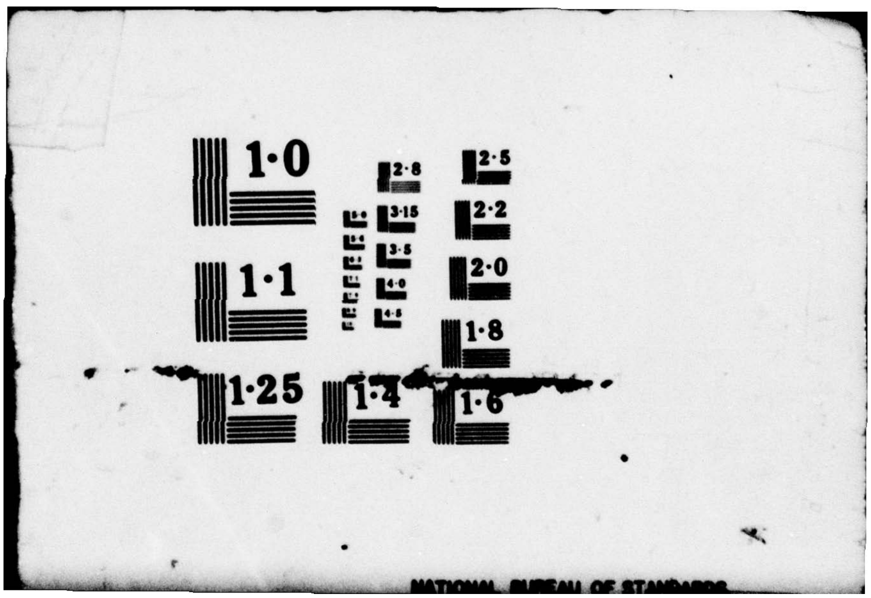

1·0
2·8
2·5
3·15
2·2
3·5
1·1
2·0
4·0
4·5
1·8
1·25
1·4
1·6
NATIONAL BUREAU OF STANDARDS

```
 * NODE CAPACITY CHANGE: TYPE IN  NODE,CAP,  ON EACH LINE, TERMINATING
   WITH <RETURN> OR TYPE AS NODE,CAP,NODE,CAP,...,-1,
   WHERE EITHER A  -1 OR TWO <RETURN>S TERMINATES
1,100,
 * NODE CAPACITY CHANGE: TYPE IN  NODE,CAP,  ON EACH LINE, TERMINATING
   WITH <RETURN> OR TYPE AS NODE,CAP,NODE,CAP,...,-1,
   WHERE EITHER A  -1 OR TWO <RETURN>S TERMINATES

 * NODE CAPACITY CHANGE:  NODE=  1  OLD CAP=220  NEW CAP =100*
ENTER PERTURBATION OPTION
1
* ALL PERTURBATIONS RESET *
ENTER PERTURBATION OPTION
```

```
                    *** RUN OPTIONS ***

TO START NORMAL RUN                                              TYPE  1
TO TERMINATE RUN AND REEXECUTE                                   TYPE  2
TO INITIATE CONTROLLER INTERACTION                               TYPE  3
TO INITIATE NETWORK PERTURBATION                                 TYPE  4
TO CHANGE PROGRAM TIME SCALE                                     TYPE  5
TO PARTIALLY INITIALIZE NETWORK AND ENVIRONMENT AND THEN RUN     TYPE  6
TO ABORT PROGRAM EXECUTION                                       TYPE  9
5
ENTER TIME SCALE MULTIPLIER AS <XXX,>
  (REAL TIME OPERATION IS A TIME SCALE OF 1)
60,
```

APPENDIX B

OVERSEAS AUTOVON NETWORK DATA

The nominal Overseas AUTOVON sizing, connectivity, routing table, and traffic data utilized with the interactive network simulator are presented in this appendix.

1.0 Network Connectivity and Sizing

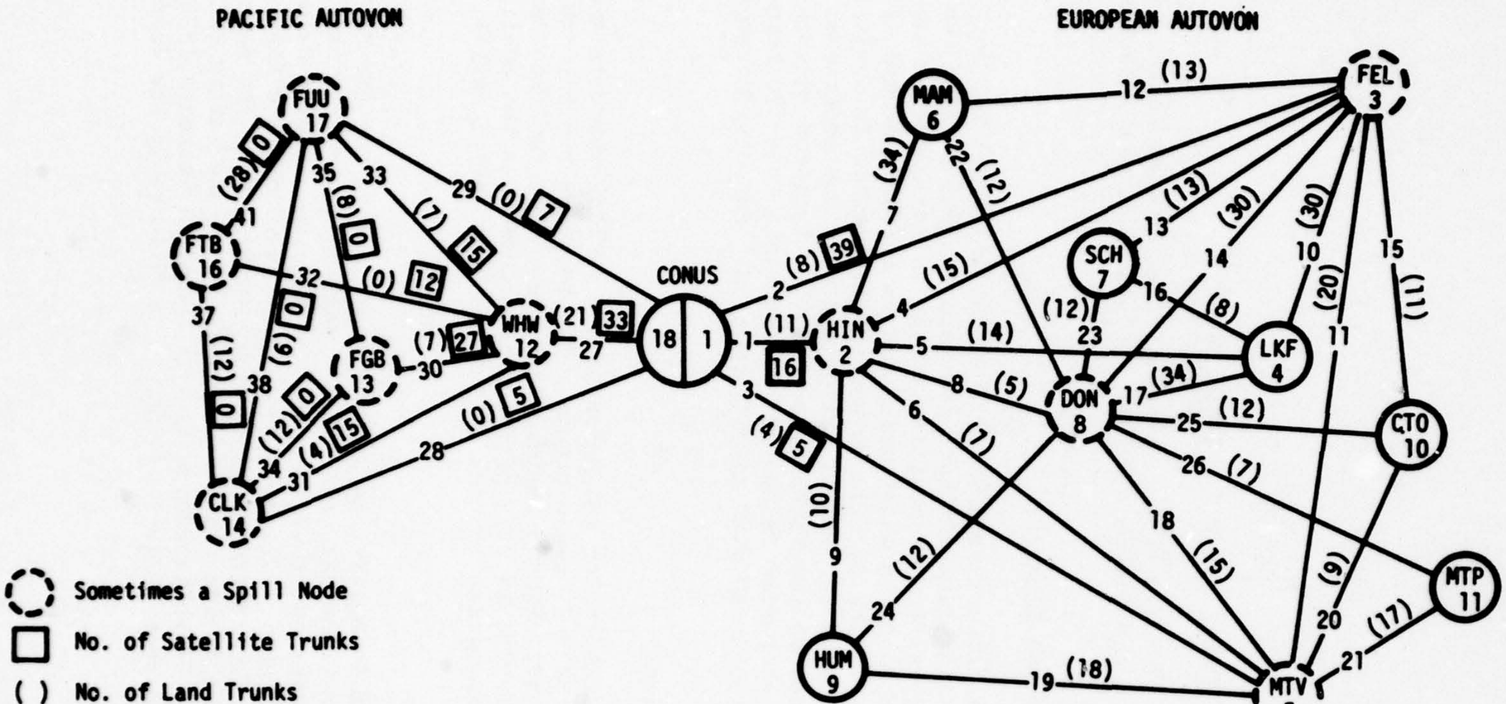
The Overseas AUTOVON network diagram illustrated in Figure B-1 contains connectivity and sizing data for both the European and Pacific theaters. Distinction between terrestrial and satellite trunks is indicated. Also indicated in the figure are nodes to which calls may be spilled forward (from certain originating nodes). The Pacific network configuration is derived from Figure 2 of DCEC TN 4-75, less the Taipei switch and with one additional trunk between the Fort Buckner and Fuchu switches. The European network configuration is the one specified in the DCA Headquarters Code 520 letter entitled "Support for European AUTOVON Reconfiguration," dated 14 November 1977.

2.0 Network Routing Tables

The nominal routing tables for the European and Pacific theaters are presented in Tables B-1 and B-2, respectively. The European routing table consists of the January 1978 AUTOVON engineered routes. The Pacific routing table is from Table II of DCEC TN 4-75 modified to accommodate the additional link of the DSCS configuration and the deletion of the Taipei switch.

3.0 Traffic Data

Tables B-3 through B-9 contain the nominal traffic data for the European and Pacific theaters. The European traffic data is taken from the DCA Headquarters Code 520 letter entitled "Support for European AUTOVON Reconfiguration," dated 14 November 1977, and is based on busy hour traffic averaged over the period from September 1976 to February 1977. The European traffic data distribution is taken from the DCA Code 530 letter entitled "European AUTOVON Traffic Reconfiguration Study," dated 24 February 1978. The Pacific data is taken from Table I of DCEC TN 4-75 (without the Taipei switch).



1. Conus Gateway to Europe
2. Hillingdon, England
3. Feldberg, Germany
4. Langerkopf, Germany
5. Mt. Vergine, Italy
6. Martlesham Heath, England
7. Schoenfeld, Germany
8. Donnersberg, Germany
9. Humosa, Spain
10. Coltano, Italy
11. Mt. Pateras, Greece
12. Wahiawa, Hawaii
13. Finegayan Bay, Guam
14. Clark AFB, Philippines
15. Ft. Buncker, Okinawa
16. Fuchu, Japan
17. Conus Gateway to Pacific

Figure B-1. Overseas AUTOVON Network

TABLE B-1. EUROPEAN AUTOVON ROUTING TABLE

***** 2: 0: 0*****

NODE TO NODE ROUTING TABLE

NS	PTH	ND1S	ND2S	ND3S	ND4S	ND5S	ND6S	ND7S	ND8S	ND9S	ND10S	ND11S
1	1	0:0	2:0	3:0	3:0	5:0	2:0	3:0	3:0	5:0	5:0	5:0
	2	0:0	3:0	2:0	2:0	3:0	3:0	2:0	5:0	2:0	3:0	3:0
	3	0:0	5:0	5:0	5:0	2:0	5:0	5:0	2:0	3:0	2:0	2:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
2	1	1:1	0:0	3:1	4:1	5:1	6:1	4:1	8:1	9:1	5:1	5:1
	2	3:1	0:0	6:1	3:1	3:1	0:0	3:1	6:1	4:1	3:1	6:1
	3	5:1	0:0	0:0	0:0	0:0	0:0	0:0	3:1	3:1	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
3	1	1:1	2:1	0:0	4:1	5:1	6:1	7:1	8:1	5:1	10:1	5:1
	2	2:1	6:1	0:0	8:1	8:1	8:1	8:1	4:1	8:1	8:1	8:1
	3	5:1	0:0	0:0	0:0	0:0	0:0	0:0	0:0	2:1	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
4	1	3:1	2:1	3:1	0:0	8:1	8:1	7:1	8:1	8:1	8:1	8:1
	2	2:1	3:1	8:1	0:0	3:1	2:1	8:1	7:1	3:1	3:1	3:1
	3	0:0	0:0	0:0	0:0	0:0	3:1	3:1	3:1	2:1	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
5	1	1:1	2:1	3:1	8:1	0:0	8:1	8:1	8:1	9:1	10:1	11:1
	2	3:1	3:1	8:1	3:1	0:0	2:1	3:1	10:1	2:1	3:1	0:0
	3	2:1	0:0	0:0	0:0	0:0	3:1	0:0	3:1	8:1	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
6	1	2:1	2:1	3:1	8:1	8:1	0:0	8:1	8:1	2:1	8:1	8:1
	2	3:1	0:0	8:1	2:1	2:1	0:0	3:1	3:1	8:1	3:1	2:1
	3	0:0	0:0	0:0	3:1	3:1	0:0	0:0	0:0	3:1	0:0	3:1
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
7	1	3:1	4:1	3:1	4:1	8:0	8:0	0:0	8:1	8:0	8:0	8:0
	2	8:0	3:1	8:0	8:0	3:1	3:1	0:0	4:1	3:1	3:1	3:1
	3	0:0	0:0	0:0	3:1	0:0	0:0	0:0	3:1	0:0	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
8	1	3:1	2:1	3:1	4:1	5:1	6:1	7:1	0:0	9:1	10:1	11:1
	2	2:1	6:1	4:1	3:1	10:1	2:1	4:1	0:0	5:1	3:1	10:1
	3	5:1	3:1	0:0	0:0	3:1	3:1	3:1	0:0	3:1	0:0	5:1
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
9	1	2:1	2:1	8:1	8:1	5:1	2:1	8:1	8:1	0:0	5:0	5:0
	2	5:0	5:0	5:0	5:0	2:1	5:0	5:0	5:0	0:0	8:1	8:1
	3	0:0	0:0	2:1	2:1	0:0	0:0	2:1	2:1	0:0	2:1	0:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
10	1	5:1	5:1	3:1	8:1	5:1	8:1	8:1	8:1	5:1	0:0	5:1
	2	3:1	3:1	8:1	3:1	3:1	3:1	3:1	3:1	8:1	0:0	8:1
	3	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
11	1	5:0	5:0	8:1	8:1	5:1	5:0	8:1	8:1	5:0	5:0	0:0
	2	0:0	0:0	5:0	5:0	0:0	0:0	5:0	5:0	0:0	0:0	0:0
	3	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0

TABLE B-2. PACIFIC AUTOVON ROUTING TABLE

***** 2: 0: 0*****

NODE TO NODE ROUTING TABLE

NS	PTH	ND12S	ND13S	ND14S	ND15S	ND16S	ND17S	ND18S
12	1	0:0	13:1	14:1	0:0	16:1	17:1	18:1
	2	0:0	0:0	16:0	0:0	17:0	16:0	0:0
	3	0:0	0:0	13:0	0:0	14:0	13:0	0:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0
13	1	12:1	0:0	14:1	0:0	14:2	17:1	12:0
	2	0:0	0:0	0:0	0:0	17:1	0:0	0:0
	3	0:0	0:0	0:0	0:0	0:0	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0
14	1	12:1	13:1	0:0	0:0	16:1	17:1	18:1
	2	13:1	0:0	0:0	0:0	0:0	16:1	12:0
	3	0:0	0:0	0:0	0:0	0:0	0:0	13:1
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0
15	1	0:0	0:0	0:0	0:0	0:0	0:0	0:0
	2	0:0	0:0	0:0	0:0	0:0	0:0	0:0
	3	0:0	0:0	0:0	0:0	0:0	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0
16	1	12:1	17:1	14:1	0:0	0:0	17:1	12:0
	2	17:1	14:0	0:0	0:0	0:0	0:0	17:2
	3	14:0	0:0	0:0	0:0	0:0	0:0	14:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0
17	1	12:1	13:1	14:1	0:0	16:1	0:0	18:1
	2	13:1	0:0	16:2	0:0	0:0	0:0	12:0
	3	0:0	0:0	0:0	0:0	0:0	0:0	13:1
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0
18	1	12:1	12:0	14:1	0:0	12:0	17:1	0:0
	2	0:0	0:0	12:0	0:0	17:0	12:0	0:0
	3	0:0	0:0	0:0	0:0	14:0	0:0	0:0
	4	0:0	0:0	0:0	0:0	0:0	0:0	0:0

TABLE B-3. EUROPEAN AUTOVON TRAFFIC TOTALS FOR ALL PRIORITIES (ERLANGS)

TO / FROM	CON	HIN	MAM	SCH	FEL	DON	LKF	HUM	CTO	MTV	MTP
CON	-	6.35	2.65	1.10	6.35	5.85	6.85	3.45	0.55	3.05	2.10
HIN	12.00	-	3.40	0.20	0.10	2.70	0.90	0.40	0.05	0.05	0.40
MAM	5.40	0.80	-	0.20	0.40	5.60	2.00	1.30	0.50	0.05	0.30
SCH	2.10	0.10	0.40	-	1.30	2.80	1.90	0.70	0.40	0.0	0.0
FEL	12.00	0.05	0.50	3.50	-	8.70	5.70	0.30	1.80	0.60	1.10
DON	15.70	0.50	1.40	1.10	5.60	-	5.10	0.80	1.20	1.30	0.20
LKF	15.00	0.50	2.00	2.00	7.90	4.50	-	1.90	1.00	0.70	0.70
HUM	6.20	0.50	1.10	1.20	1.00	2.10	1.60	-	1.00	1.10	0.50
CTO	1.50	0.05	0.05	0.40	4.10	3.20	1.30	0.90	-	0.60	0.50
MTV	6.10	0.05	0.10	0.20	1.00	2.00	1.30	0.60	1.20	-	0.40
MTP	5.40	0.50	0.10	0.10	2.60	2.00	1.50	0.90	0.05	0.50	-

TABLE B-4. EUROPEAN AUTOVON TRAFFIC OFFERED FOR PRIORITY 0: FLASH OVERRIDE (ERLANGS)

TO / FROM	CON	HIN	MAM	SCH	FEL	DON	LKF	HUM	CTO	MTV	MTP
CON	-	0.0012	0.0005	0.0002	0.0012	0.0011	0.0013	0.0006	0.0001	0.0006	0.0004
HIN	0.0024	-	0.0001	0.00001	0.000005	0.00001	0.00004	0.00002	0.000002	0.000002	0.00002
MAN	0.001	0.00004	-	0.00001	0.00002	0.0002	0.0001	0.00006	0.00002	0.000002	0.00001
SCH	0.0004	0.000005	0.00002	-	0.00006	0.0001	0.00009	0.00003	0.00002	-	-
FEL	0.0024	0.000002	0.00002	0.0001	-	0.0004	0.0002	0.00001	0.00009	0.00003	0.00005
DON	0.0031	0.00002	0.00007	0.00005	0.0002	-	0.0002	0.00004	0.00006	0.00006	0.00001
LKF	0.003	0.00002	0.0001	0.0001	0.0003	0.0002	-	0.00009	0.00005	0.00003	0.00003
HUM	0.0012	0.00002	0.00005	0.00006	0.00005	0.0001	0.00008	-	0.00005	0.00005	0.00002
CTO	0.0003	0.000002	0.000002	0.00002	0.0002	0.0001	0.00006	0.00004	-	0.00003	0.00002
MTV	0.0012	0.000002	0.000005	0.00001	0.00005	0.0001	0.00006	0.00003	0.00006	-	0.00002
MTP	0.001	0.00002	0.000005	0.000005	0.0001	0.0001	0.00007	0.00004	0.000002	0.00002	-

NOTE:
Priority 0 traffic is assumed to be 5 percent of the total priority 0 and priority 1 traffic.

TABLE B-5. EUROPEAN AUTOVON TRAFFIC OFFERED FOR PRIORITY 1: (ERLANGS)

TO / FROM	CON	HIN	MAM	SCH	FEL	DON	LKF	HUM	CTO	MTV	MTP
CON	-	0.0241	0.010	0.0041	0.0241	0.022	0.026	0.0131	0.002	0.0115	0.0079
HIN	0.0456	-	0.0032	0.0001	0.00009	0.0025	0.0008	0.0003	0.00004	0.00004	0.0003
MAM	0.020	0.0007	-	0.0001	0.0003	0.0053	0.0019	0.0012	0.0004	0.00004	0.0002
SCH	0.0079	0.00009	0.0003	-	0.0012	0.0026	0.0018	0.0006	0.0003	0.0000	0.0000
FEL	0.0456	0.0035	0.0004	0.0033	-	0.0082	0.0054	0.0002	0.0017	0.0005	0.0010
DON	0.0596	0.0004	0.0013	0.0010	0.0053	-	0.0048	0.0007	0.0011	0.0012	0.0001
LKF	0.057	0.0004	0.0019	0.0019	0.0075	0.0042	-	0.0018	0.0009	0.0006	0.0006
HUM	0.0235	0.0004	0.001	0.0011	0.0009	0.0019	0.0015	-	0.0009	0.001	0.0004
CTO	0.0057	0.00004	0.00004	0.0003	0.0038	0.003	0.0012	0.0008	-	0.0005	0.0004
MTV	0.0231	0.00004	0.00009	0.0001	0.0009	0.0019	0.0012	0.0005	0.0011	-	0.0003
MTP	0.0205	0.0004	0.00009	0.00009	0.0024	0.0019	0.0014	0.0008	0.00004	0.0004	-

TABLE B-6. EUROPEAN AUTOVON TRAFFIC OFFERED FOR PRIORITY 2: IMMEDIATE (ERLANGS)

FROM \ TO	CON	HIN	MAM	SCH	FEL	DON	LKF	HUM	CTO	MTV	MTP
CON	-	3.33	1.39	0.577	3.33	3.07	3.59	1.81	0.288	1.6	1.10
HIN	6.30	-	0.238	0.014	0.007	0.189	0.063	0.028	0.0035	0.0035	0.028
MAM	2.83	0.056	-	0.014	0.028	0.392	0.140	0.091	0.035	0.0035	0.021
SCH	1.10	0.007	0.028	-	0.091	0.196	0.133	0.049	0.028	0.0000	0.000
FEL	6.3	0.0035	0.035	0.245	-	0.609	0.399	0.021	0.126	0.042	0.077
DON	8.24	0.035	0.098	0.077	0.392	-	0.357	0.056	0.084	0.091	0.014
LKF	7.87	0.035	0.140	0.140	0.553	0.315	-	0.133	0.070	0.049	0.049
HUM	3.25	0.035	0.077	0.084	0.07	0.147	0.112	-	0.070	0.077	0.035
CTO	0.787	0.0035	0.0035	0.028	0.287	0.224	0.091	0.063	-	0.042	0.035
MTV	3.2	0.0035	0.007	0.014	0.070	0.140	0.091	0.042	0.084	-	0.028
MTP	2.83	0.035	0.007	0.007	0.182	0.140	0.105	0.063	0.0035	0.035	-

TABLE B-7. EUROPEAN AUTOVON TRAFFIC OFFERED FOR PRIORITY 3: PRIORITY (ERLANGS)

TO / FROM	CON	HIN	MAM	SCH	FEL	DON	LKF	HUM	CTO	MTV	MTP
CON	-	1.84	0.768	0.319	1.84	1.69	1.98	1.0	0.159	0.884	0.609
HIN	3.48	-	0.6188	0.0364	0.0182	0.4914	0.1638	0.0728	0.0091	0.0091	0.072
MAM	1.56	0.1456	-	0.0364	0.0728	1.019	0.3640	0.2366	0.091	0.0091	0.0546
SCH	0.609	0.0182	0.0728	-	0.2366	0.5096	0.3458	0.1274	0.0728	-	-
FEL	3.48	0.0091	0.091	0.637	-	1.58	1.03	0.0546	0.3276	0.1092	0.2002
DON	4.55	0.091	0.2548	0.2002	1.01	-	0.9282	0.1456	0.2184	0.2366	0.0364
LKF	4.35	0.091	0.3640	0.3640	1.43	0.3150	-	0.3458	0.1820	0.1274	0.1274
HUM	1.79	0.0910	0.2002	0.2184	0.1820	0.3822	0.2912	-	0.182	0.2002	0.091
CTO	0.435	0.0091	0.0091	0.0728	0.7462	0.5824	0.2366	0.1638	-	0.1092	0.091
MTV	1.76	0.0091	0.0182	0.0364	0.1820	0.3640	0.2366	0.1092	0.2184	-	0.0728
MTP	1.56	0.091	0.0182	0.0182	0.4732	0.364	0.273	0.1638	0.0091	0.091	-

TABLE B-8. EUROPEAN AUTOVON TRAFFIC OFFERED FOR PRIORITY 4: ROUTINE (ERLANGS)

TO / FROM	CON	HIN	MAM	SCH	FEL	DON	LKF	HUM	CTO	MTV	MTP
CON	-	1.14	0.4796	0.1991	1.14	1.05	1.23	0.6244	0.0995	0.552	0.3801
HIN	2.17	-	2.53	0.1494	0.0747	2.01	0.6723	0.2988	0.0373	0.0373	0.2988
MAM	0.9774	0.5976	-	0.1494	0.2988	4.18	1.49	0.9711	0.3735	0.0373	0.2241
SCH	0.3801	0.0747	0.2988	-	0.9711	2.09	1.41	0.5229	0.2988	-	-
FEL	2.17	0.0373	0.3735	2.61	-	6.49	4.25	0.2241	1.34	0.448	0.8217
DON	2.84	0.3735	1.04	0.8217	4.18	-	3.809	0.5976	0.8964	0.9711	0.1494
LKF	2.71	0.3735	1.49	1.49	5.90	3.36	-	1.41	0.747	0.5229	0.5229
HUM	1.12	0.3735	0.8217	0.8964	0.747	1.56	1.19	-	0.747	0.8217	0.3735
CTO	0.2715	0.3735	0.0373	0.2988	3.06	2.39	0.9711	0.6723	-	0.4482	0.3735
MTV	1.10	0.0373	0.0747	0.1494	0.747	1.49	0.9711	0.4482	0.8964	-	0.2988
MTP	0.9774	0.3735	0.0747	0.0747	1.94	1.49	1.12	0.6723	0.0373	0.3735	-

TABLE B-9. PACIFIC AUTOVON TRAFFIC OFFERED (ERLANGS)

FROM \ TO	PRIORITY	CON (18)	WHW (12)	FGB (13)	CLK (14)	FTB (16)	FUU (17)
CON (18)	T		6.7000	2.9000	5.4000	6.1000	2.3000
	0		0.0067	0.0028	0.0053	0.0061	0.0022
	1		0.0669	0.0292	0.0542	0.0611	0.0231
	2		2.2714	0.2581	0.4806	0.5428	0.2047
	3		3.3500	1.1600	2.1600	2.4400	0.9200
	4		1.0050	1.4500	2.7000	3.0500	1.1500
WHW (12)	T	6.7000		2.5000	12.3000	5.1000	10.9000
	0	0.0067		0.0025	0.0122	0.0050	0.0109
	1	0.0669		0.0250	0.1231	0.0511	0.1090
	2	2.2714		0.8475	4.1697	1.7289	3.6950
	3	3.3500		1.2500	6.1500	2.5500	5.4500
	4	1.0050		0.3750	1.8450	0.7650	1.6350
FGB (13)	T	2.9000	2.4000		4.8000	0.9000	2.2000
	0	0.0000	0.0000		0.0000	0.0000	0.0000
	1	0.0292	0.0240		0.0481	0.0089	0.0220
	2	0.2608	0.8161		0.4319	0.0811	0.1980
	3	1.1600	1.2000		2.4961	0.4681	1.1440
	4	1.4500	0.3600		1.8239	0.3419	0.8360
CLK (14)	T	5.4000	7.3000	1.8000		3.4000	3.7000
	0	0.0000	0.0000	0.0000		0.0000	0.0000
	1	0.0542	0.0730	0.0180		0.0339	0.0370
	2	0.4858	2.4819	0.1620		0.3061	0.3330
	3	2.1600	3.6500	0.9360		1.7681	1.9240
	4	2.7000	1.0950	0.6840		1.2919	1.4060
FTB (16)	T	6.1000	7.2000	0.7000	4.0000		3.0000
	0	0.0000	0.0000	0.0000	0.0000		0.0000
	1	0.0611	0.0719	0.0070	0.0400		0.0300
	2	0.5489	2.4481	0.0630	0.3600		0.2700
	3	2.4400	3.6000	0.3639	2.0800		1.5600
	4	3.0500	1.0800	0.2661	1.5200		1.1400
FUU (17)	T	2.3000	14.5000	3.1000	3.5000	3.0000	
	0	0.0000	0.0000	0.0000	0.0000	0.0000	
	1	0.0231	0.1450	0.0311	0.0350	0.0300	
	2	0.2069	4.9300	0.2789	0.3150	0.2700	
	3	0.9200	7.2500	1.6119	1.8200	1.5600	
	4	1.1500	2.1750	1.1781	1.3300	1.1400	

APPENDIX C

OVERSEAS AUTOVON BASELINE SCENARIO

The interactive network simulator baseline scenario for the Overseas AUTOVON network is illustrated in this appendix. The network configuration for this scenario is defined in appendix B. Figure C-1 contains the digital documentation of the scenario and includes a summary of run parameters and network statistics for the 2-hour run. Figure C-2 illustrates stripplot data of link percent utilization, windowed link grade of service, and windowed network grade of service by priority. The grade of service window for this scenario is 10 minutes. These display formats are explained in detail in section 1.5.

```
**********RUN= 3**********

NETWORK CONFIGURATION IS OVERSEAS
RUN TIME     DATE=06/09/78  TIME=15:58:00
RUN LENGTH (SEC) =  7200     SYNC INDICATOR = 1     TIME SCALE =  60
RANDOM NUMBER SEEDS <IXO(6)> :
          1         101         1001          51          151          1051
NUMBER FRAMES/MIN =   60     AVG CALL DURATION (MIN) =  2.80
NUMBER TIME INTERVALS/FRAME =   1     SWITCH OPTIONS:  7E100000
LINKS = 41     NODES = 18     MAX CC = 256     MAX PATHS(WORDS)/NODE = 4(4)
ROUTING METHOD =  3     TRAFFIC LOAD FACTOR =    1.00
MAX RECALLS =  5     PREMPTED CALL REPLACEMENT = 0
AVG TIME BETWEEN RECALLS 1-15 :
      0.25    2.00    6.75   16.00   31.25   54.00   85.75  128.00
    182.25  250.00  332.75  432.00  549.25  686.00  843.75
PRIORITIES = 5   ROUTINE PRECEDENCE = 4   LOWEST PREMPTING PRIORITY = 3
INPUT/OUTPUT DEVICE ASSIGNMENTS
  IUM,IUC,IUD,IUP,IUN,IULC,IULD,IURM,IURP  10 10 10 10 10 10 10 10 10
  OUM,OUC,OUD,OUP,OUN,OULC,OULD,OURM,OURP  11 11 11 11 11 11 11 11 11
  IPSUM,IPWRK,IPDOC,ICRD,ITEK,IOHCPY        6     6     6    13     3     3
STRIPPLOT SETUP      TYPE/NUMBER
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16
IDTST=  1  NST= 16  ICAL=  0  OUSTR=  8


         ***** END OF RUN   3 *****


*INPUT DATA*3
*INPUT DATA*3
*INPUT DATA*5
                          ***** 2: 0: 0*****
               *ACCUMULATED TOTAL NETWORK STATISTICS*
          ATTEMPTS BLOCKS COMPLETE PREEMPTED BL/ATT PR/COM
             18717   2330    16387      2588 0.1245 0.1579
*INPUT DATA*6
                          ***** 2: 0: 0*****
             *ACCUMULATED NETWORK PRECEDENCE STATISTICS*
     PREC ATTEMPTS BLOCKS COMPLETE PREEMPTED BL/ATT PR/COM PREC
       0         4      0        4         0 0.0000 0.0000    0
       1        68      0       68         0 0.0000 0.0000    1
       2      4435     19     4416         0 0.0043 0.0000    2
       3      6221    823     5398       926 0.1323 0.1715    3
       4      7989   1488     6501      1662 0.1863 0.2557    4
```

Figure C-1. Overseas AUTOVON Baseline Scenario Digital Displays

***** 2: 0: 0*****

ACCUMULATED SOURCE NODE NETWORK STATISTICS

NODE	ATTEMPTS	BLOCKS	COMPLETE	PREEMPTED	BL/ATT	PR/COM	NODE
1	2090	385	1705	511	0.1842	0.2997	1
2	960	129	831	184	0.1344	0.2214	2
3	1586	138	1448	235	0.0870	0.1623	3
4	1689	145	1544	199	0.0858	0.1289	4
5	591	55	536	82	0.0931	0.1530	5
6	829	99	730	83	0.1194	0.1137	6
7	450	25	425	25	0.0556	0.0588	7
8	1627	221	1406	272	0.1358	0.1935	8
9	724	58	666	96	0.0801	0.1441	9
10	531	22	509	17	0.0414	0.0334	10
11	654	69	585	102	0.1055	0.1744	11
12	1642	84	1558	140	0.0512	0.0899	12
13	759	227	532	65	0.2991	0.1222	13
14	1041	168	873	115	0.1614	0.1317	14
16	953	89	864	139	0.0934	0.1609	16
17	1557	356	1201	180	0.2286	0.1499	17
18	1034	60	974	143	0.0580	0.1468	18

***** 2: 0: 0*****

*ACCUMULATED LINK/PRIORITY GOS STATUS

LINK A	TOTAL	P0	P1	P2	P3	P4
	BLCK/ATTM=X.XX	BLCK/ATTM	BLCK/ATTM	BLCK/ATTM	BLCK/ATTM	BLCK/ATTM
1**	3824/5496=0.70	1/ 3	12/ 17	1415/2256	1565/2089	831/1131
2**	4186/7076=0.59	1/ 1	9/ 22	1539/3144	1753/2562	884/1347
3***	3541/4127=0.86	1/ 1	9/ 10	1366/1692	1438/1607	727/ 817
4	0/1125=0.00	0/ 1	0/ 5	0/ 424	0/ 425	0/ 270
5	3/ 793=0.00	0/ 0	0/ 3	0/ 276	1/ 270	2/ 244
6	40/1071=0.04	0/ 1	0/ 1	11/ 354	17/ 456	12/ 259
7	0/ 920=0.00	0/ 0	0/ 2	0/ 263	0/ 245	0/ 410
8 *	335/1002=0.33	0/ 0	0/ 1	115/ 327	121/ 365	99/ 309
9	13/ 509=0.03	0/ 0	0/ 2	1/ 174	5/ 148	7/ 185
10	196/2044=0.10	0/ 0	0/ 5	48/ 709	47/ 553	101/ 777
11	16/1633=0.01	0/ 0	0/ 7	7/ 593	5/ 583	4/ 450
12	0/ 443=0.00	0/ 0	0/ 1	0/ 113	0/ 152	0/ 177
13	0/ 392=0.00	0/ 0	0/ 0	0/ 111	0/ 74	0/ 207
14	348/2483=0.14	0/ 0	0/ 3	83/ 770	79/ 682	186/1028
15	24/ 362=0.07	0/ 0	0/ 0	5/ 48	3/ 87	16/ 227
16	8/ 209=0.04	0/ 0	0/ 0	1/ 21	1/ 45	6/ 143
17	39/1206=0.03	0/ 0	0/ 0	2/ 90	8/ 215	29/ 901
18	0/ 993=0.00	0/ 0	0/ 1	0/ 277	0/ 350	0/ 365
19	0/ 531=0.00	0/ 0	0/ 3	0/ 144	0/ 130	0/ 254
20	9/ 292=0.03	0/ 0	0/ 0	2/ 68	2/ 77	5/ 147
21	9/ 681=0.01	0/ 0	0/ 2	2/ 179	2/ 186	5/ 314
22 *	227/ 662=0.34	0/ 0	0/ 0	14/ 48	40/ 120	173/ 494
23	31/ 419=0.07	0/ 0	0/ 0	3/ 59	5/ 87	23/ 273
24	23/ 381=0.06	0/ 0	0/ 0	1/ 21	3/ 71	19/ 289
25	22/ 384=0.06	0/ 0	0/ 0	0/ 24	5/ 61	17/ 299
26	69/ 326=0.21	0/ 0	0/ 0	6/ 33	12/ 57	51/ 236
27	0/1543=0.00	0/ 0	0/ 8	0/ 265	0/ 649	0/ 621
28**	349/ 561=0.62	0/ 0	1/ 6	25/ 48	129/ 211	194/ 296
29 *	170/ 439=0.39	0/ 0	2/ 7	12/ 39	58/ 168	98/ 225
30	0/1149=0.00	0/ 0	0/ 9	0/ 256	0/ 567	0/ 317
31 *	588/1543=0.38	0/ 0	5/ 14	142/ 395	248/ 707	193/ 427
32**	1154/1812=0.64	0/ 1	7/ 13	241/ 399	557/ 861	349/ 538
33**	1231/2396=0.51	1/ 2	5/ 10	242/ 602	716/1286	267/ 496
34 *	484/1024=0.47	0/ 0	3/ 7	75/ 151	191/ 448	215/ 418
35**	1145/1590=0.72	0/ 0	3/ 6	128/ 190	715/ 976	299/ 418
37 *	517/1146=0.45	0/ 0	5/ 9	52/ 129	265/ 595	195/ 413
38 *	171/ 387=0.44	0/ 0	2/ 4	11/ 28	87/ 202	71/ 153
41	0/1097=0.00	0/ 1	0/ 6	0/ 170	0/ 549	0/ 371

Figure C-1. (cont)

***** 2: 0: 0*****

ACCUMULATED LINK/PRIORITY PREEMPTION STATUS

LINK	A	TOTAL	P0	P1	P2	P3	P4
		PREM/COMP=X.XX	PREM/COMP	PREM/COMP	PREM/COMP	PREM/COMP	PREM/COMP
1		478/1672=0.29	0/ 2	0/ 5	0/ 841	218/ 524	260/ 300
2	*	906/2890=0.31	0/ 0	0/ 13	0/1605	492/ 809	414/ 463
3	*	193/ 586=0.33	0/ 0	0/ 1	0/ 326	110/ 169	83/ 90
4		0/1125=0.00	0/ 1	0/ 5	0/ 424	0/ 425	0/ 270
5		0/ 790=0.00	0/ 0	0/ 3	0/ 276	0/ 269	0/ 242
6		9/1031=0.01	0/ 1	0/ 1	0/ 343	1/ 439	8/ 247
7		0/ 920=0.00	0/ 0	0/ 2	0/ 263	0/ 245	0/ 410
8		40/ 667=0.06	0/ 0	0/ 1	0/ 212	3/ 244	37/ 210
9		0/ 496=0.00	0/ 0	0/ 2	0/ 173	0/ 143	0/ 178
10		63/1848=0.03	0/ 0	0/ 5	0/ 661	0/ 506	63/ 676
11		8/1617=0.00	0/ 0	0/ 7	0/ 586	0/ 578	8/ 446
12		0/ 443=0.00	0/ 0	0/ 1	0/ 113	0/ 152	0/ 177
13		0/ 392=0.00	0/ 0	0/ 0	0/ 111	0/ 74	0/ 207
14		96/2135=0.04	0/ 0	0/ 3	0/ 687	0/ 603	96/ 842
15		2/ 338=0.01	0/ 0	0/ 0	0/ 43	0/ 84	2/ 211
16		0/ 201=0.00	0/ 0	0/ 0	0/ 20	0/ 44	0/ 137
17		0/1167=0.00	0/ 0	0/ 0	0/ 88	0/ 207	0/ 872
18		0/ 993=0.00	0/ 0	0/ 1	0/ 277	0/ 350	0/ 365
19		0/ 531=0.00	0/ 0	0/ 3	0/ 144	0/ 130	0/ 254
20		1/ 283=0.00	0/ 0	0/ 0	0/ 66	0/ 75	1/ 142
21		2/ 672=0.00	0/ 0	0/ 2	0/ 177	0/ 184	2/ 309
22		3/ 435=0.01	0/ 0	0/ 0	0/ 34	0/ 80	3/ 321
23		2/ 388=0.01	0/ 0	0/ 0	0/ 56	0/ 82	2/ 250
24		0/ 358=0.00	0/ 0	0/ 0	0/ 20	0/ 68	0/ 270
25		0/ 362=0.00	0/ 0	0/ 0	0/ 24	0/ 56	0/ 282
26		3/ 257=0.01	0/ 0	0/ 0	0/ 27	0/ 45	3/ 185
27		0/1543=0.00	0/ 0	0/ 8	0/ 265	0/ 649	0/ 621
28		17/ 212=0.08	0/ 0	0/ 5	0/ 23	0/ 82	17/ 102
29		15/ 269=0.06	0/ 0	0/ 5	0/ 27	0/ 110	15/ 127
30		0/1149=0.00	0/ 0	0/ 9	0/ 256	0/ 567	0/ 317
31		114/ 955=0.12	0/ 0	0/ 9	0/ 253	16/ 459	98/ 234
32		121/ 658=0.18	0/ 1	0/ 6	0/ 158	17/ 304	104/ 189
33		226/1165=0.19	0/ 1	0/ 5	0/ 360	53/ 570	173/ 229
34		76/ 540=0.14	0/ 0	0/ 4	0/ 76	4/ 257	72/ 203
35		96/ 445=0.22	0/ 0	0/ 3	0/ 62	9/ 261	87/ 119
37		93/ 629=0.15	0/ 0	0/ 4	0/ 77	3/ 330	90/ 218
38		24/ 216=0.11	0/ 0	0/ 2	0/ 17	0/ 115	24/ 82
41		0/1097=0.00	0/ 1	0/ 6	0/ 170	0/ 549	0/ 371

Figure C-1. (cont)

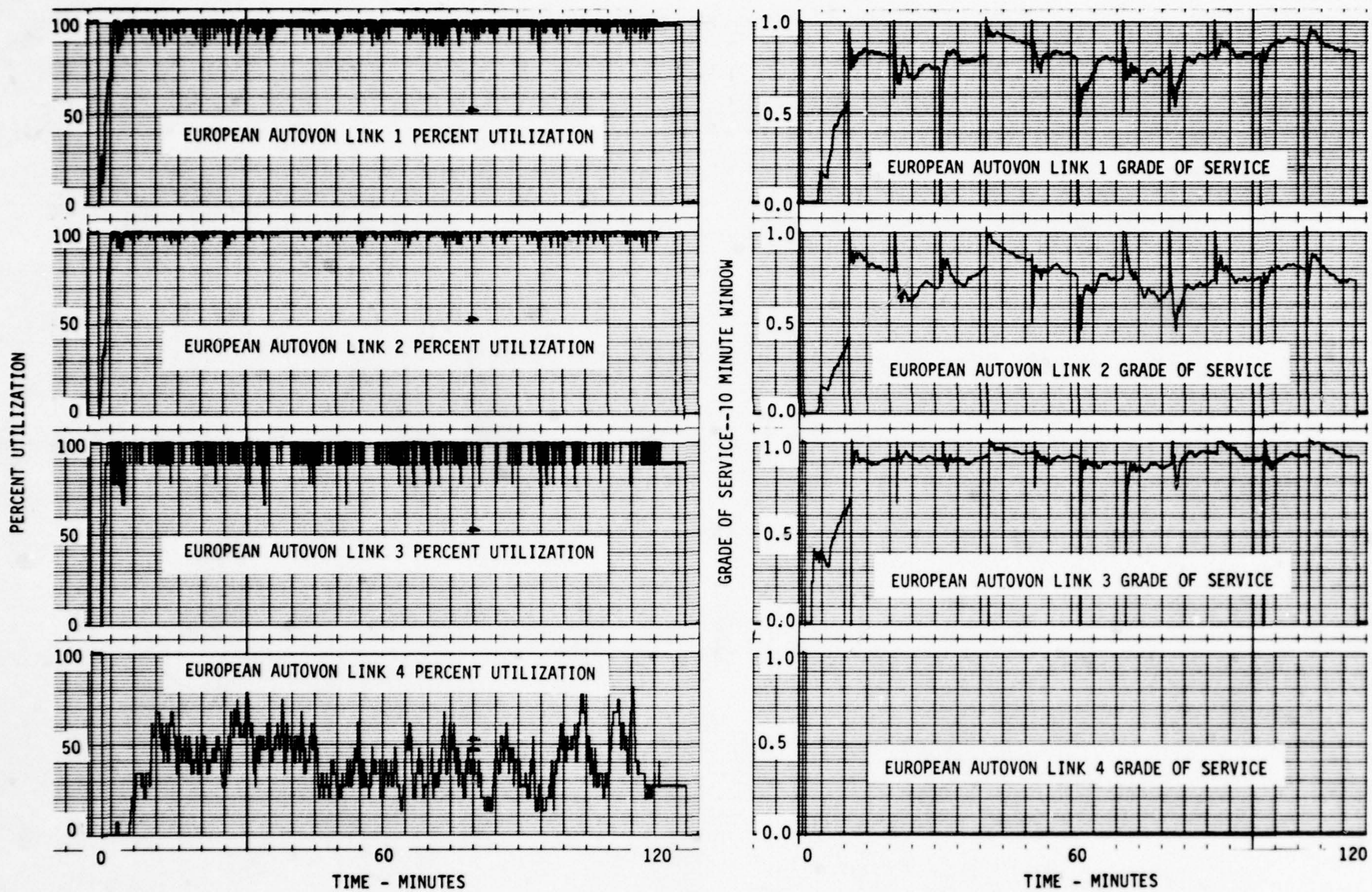


Figure C-2. Overseas AUTOVON Baseline Scenario Stripchart Data

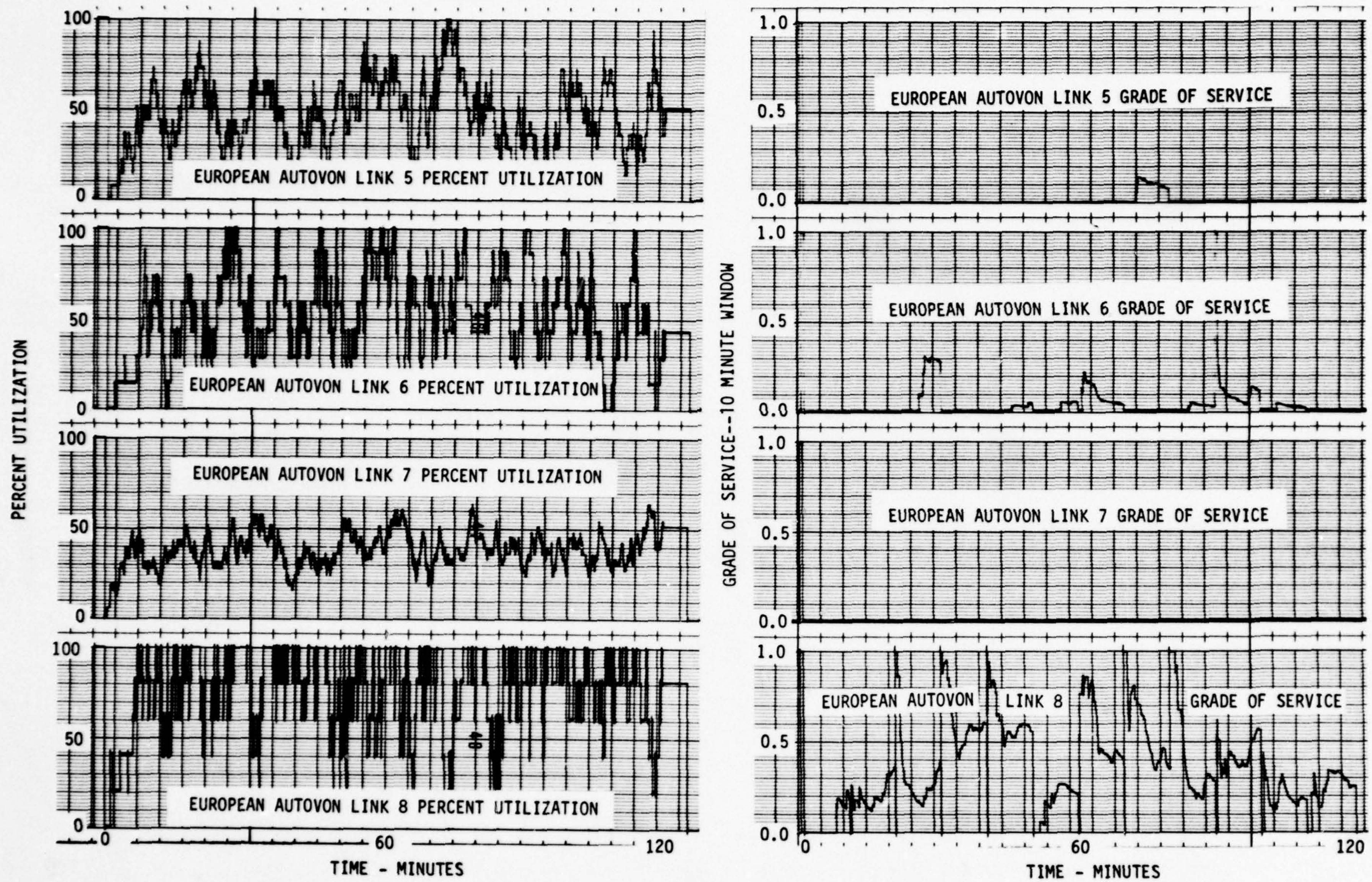


Figure C-2. (cont)

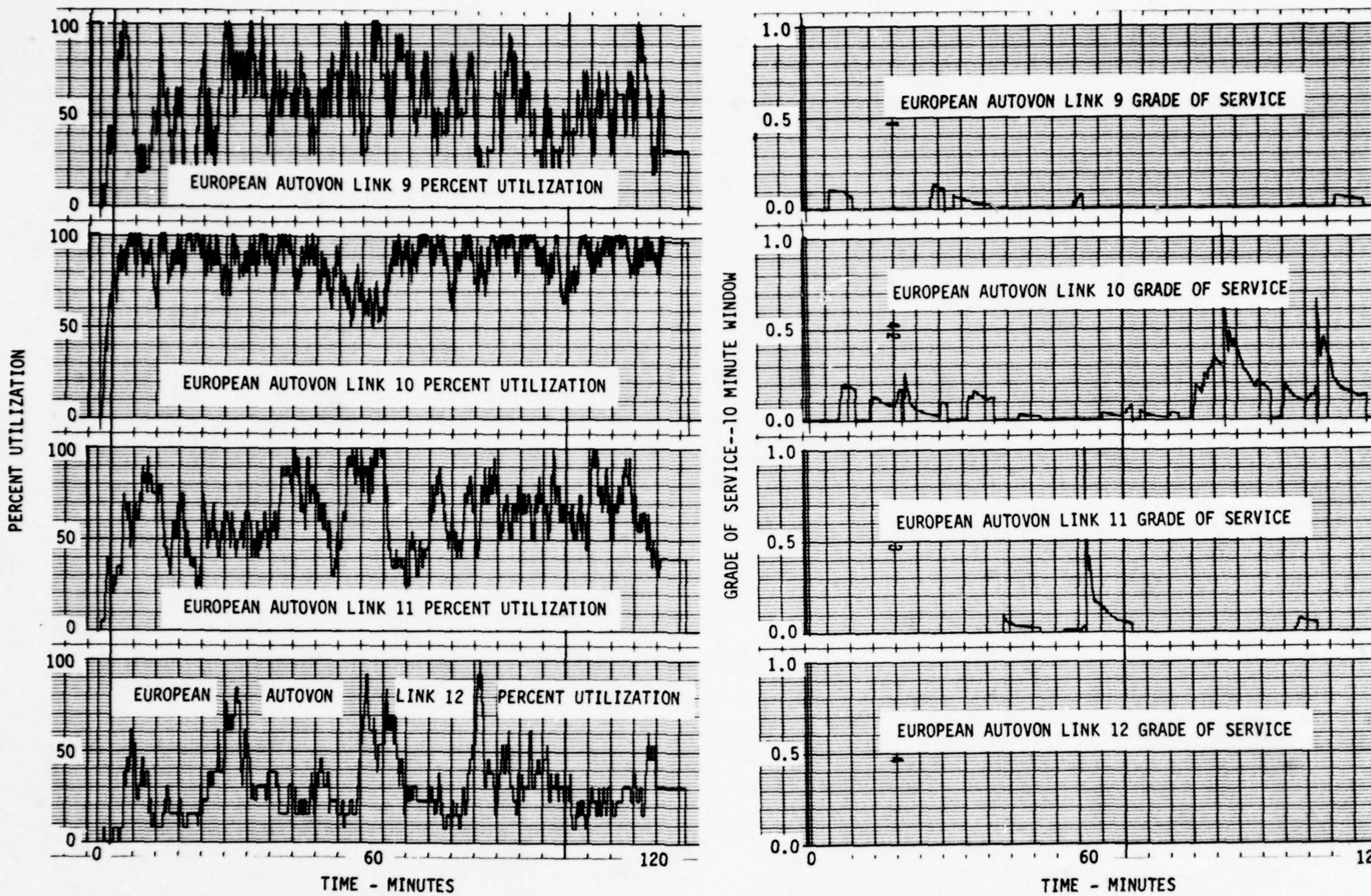


Figure C-2. (cont)

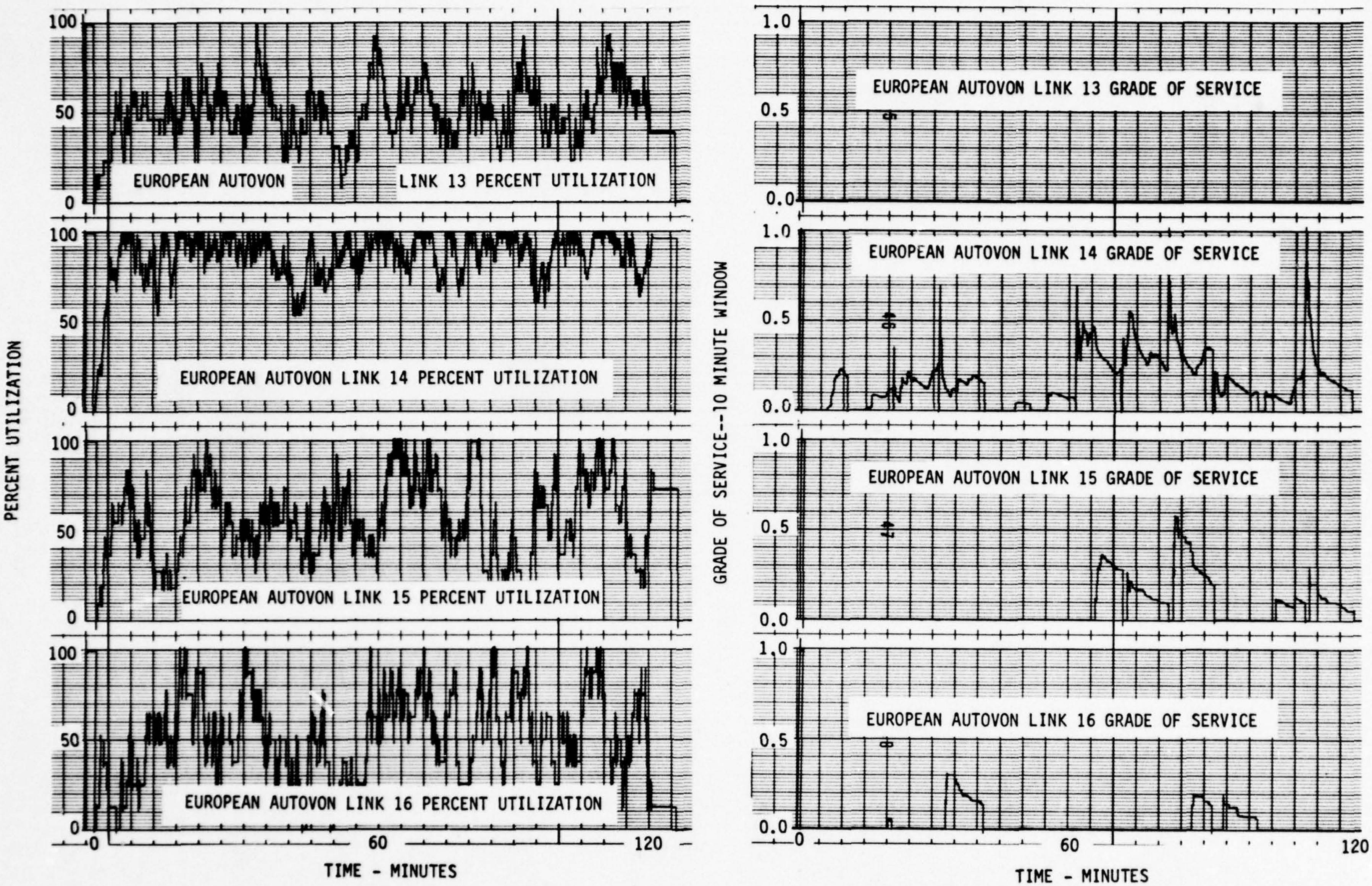


Figure C-2. (cont)

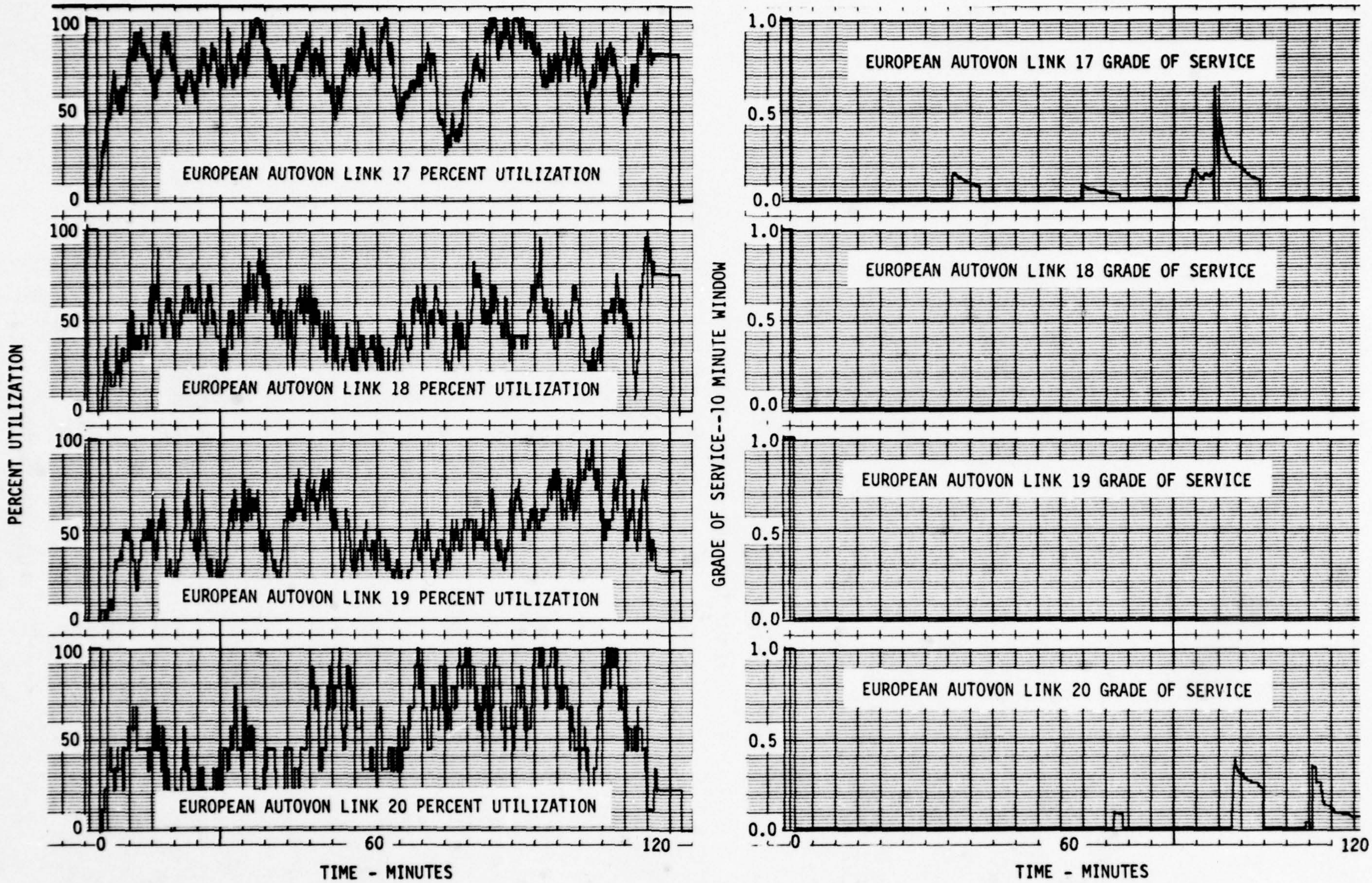


Figure C-2. (cont)

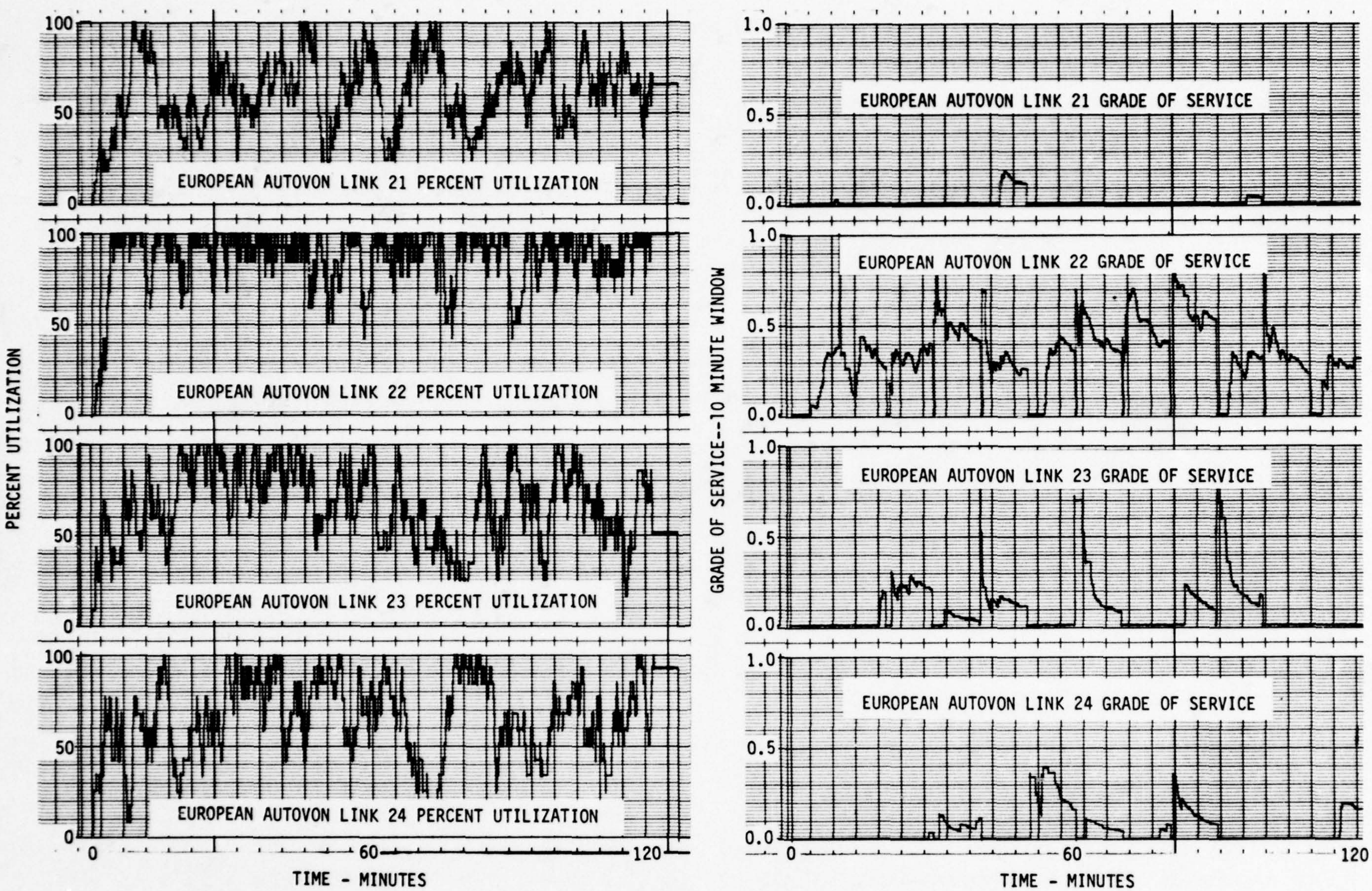


Figure C-2. (cont)

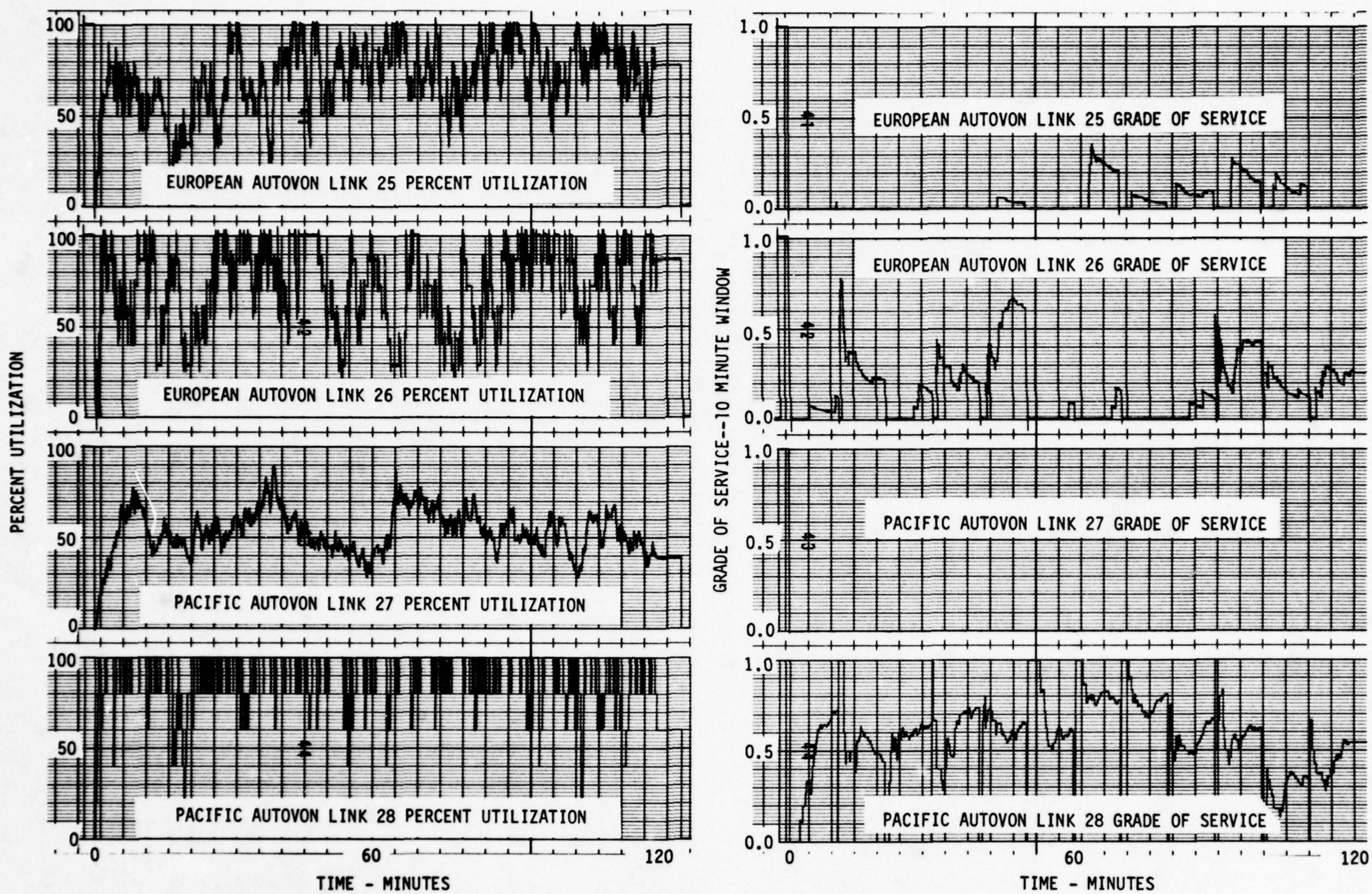


Figure C-2. (cont)

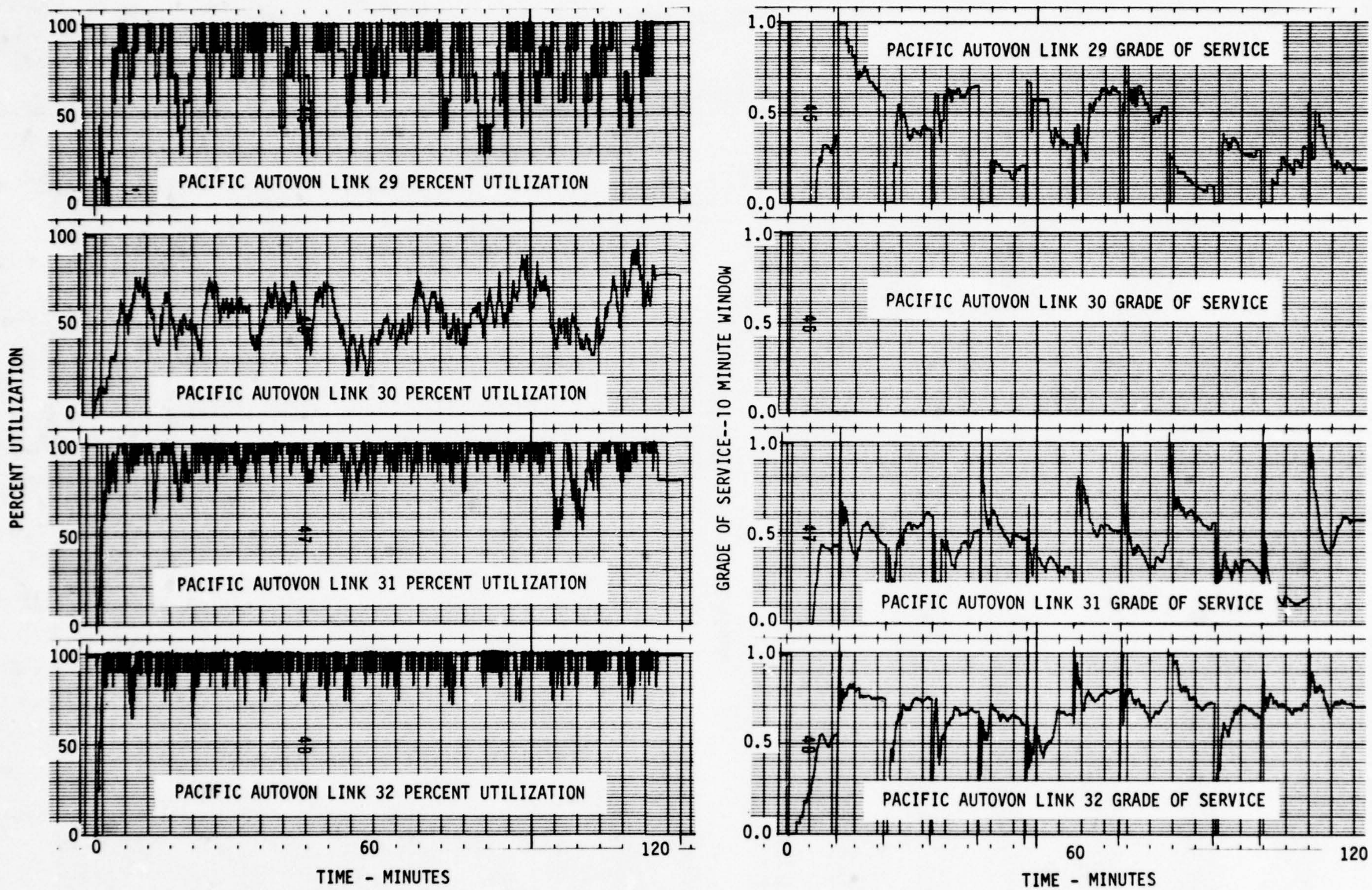


Figure C-2. (cont)

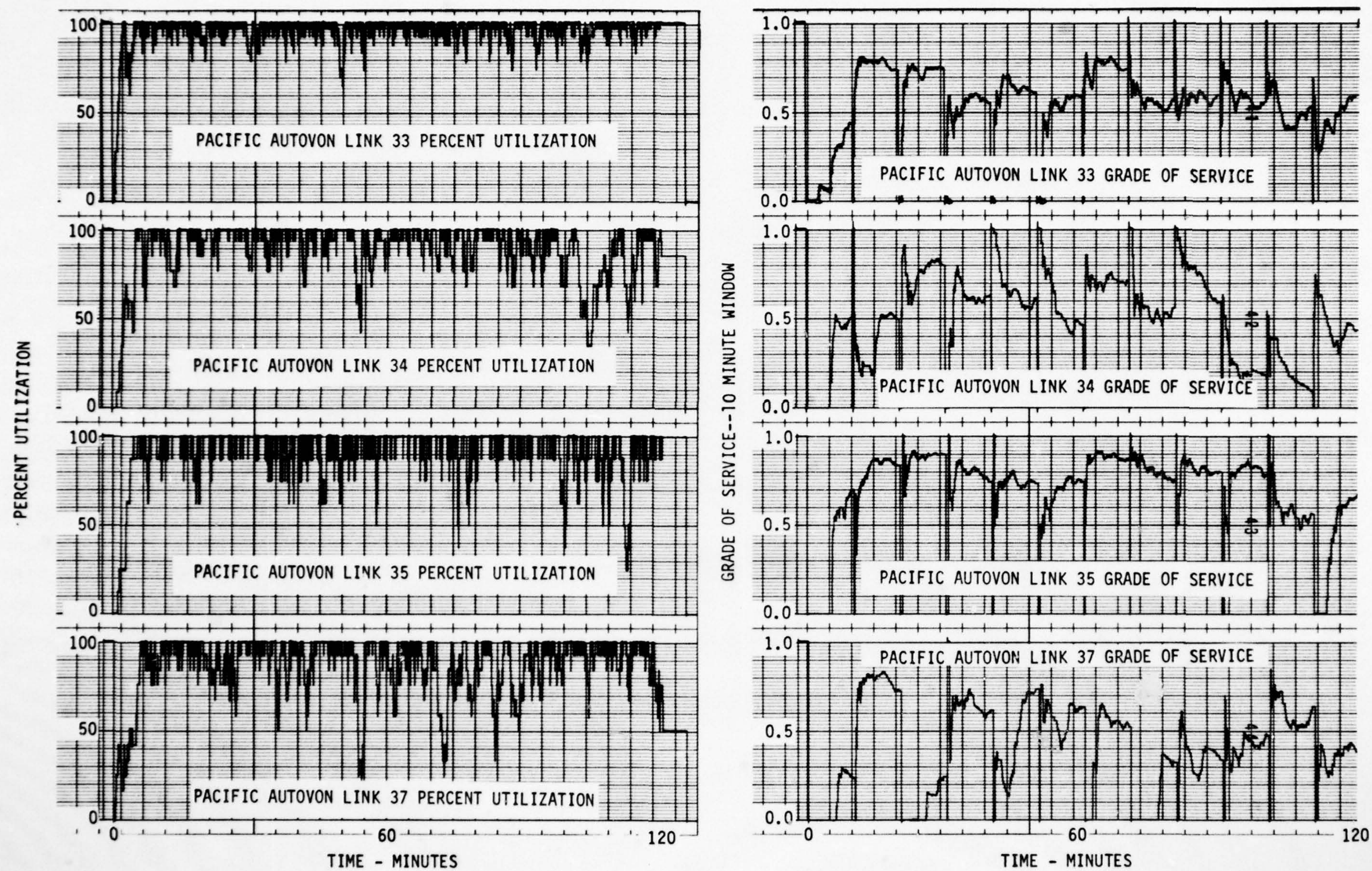


Figure C-2. (cont)

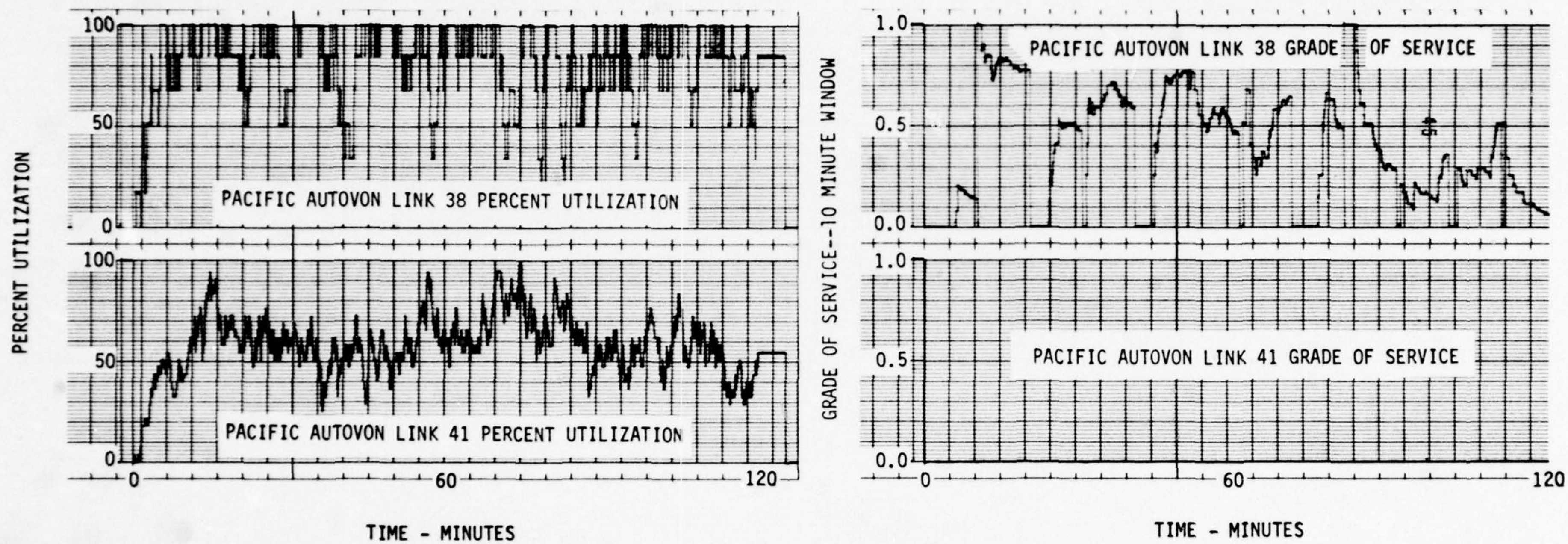


Figure C-2. (cont)

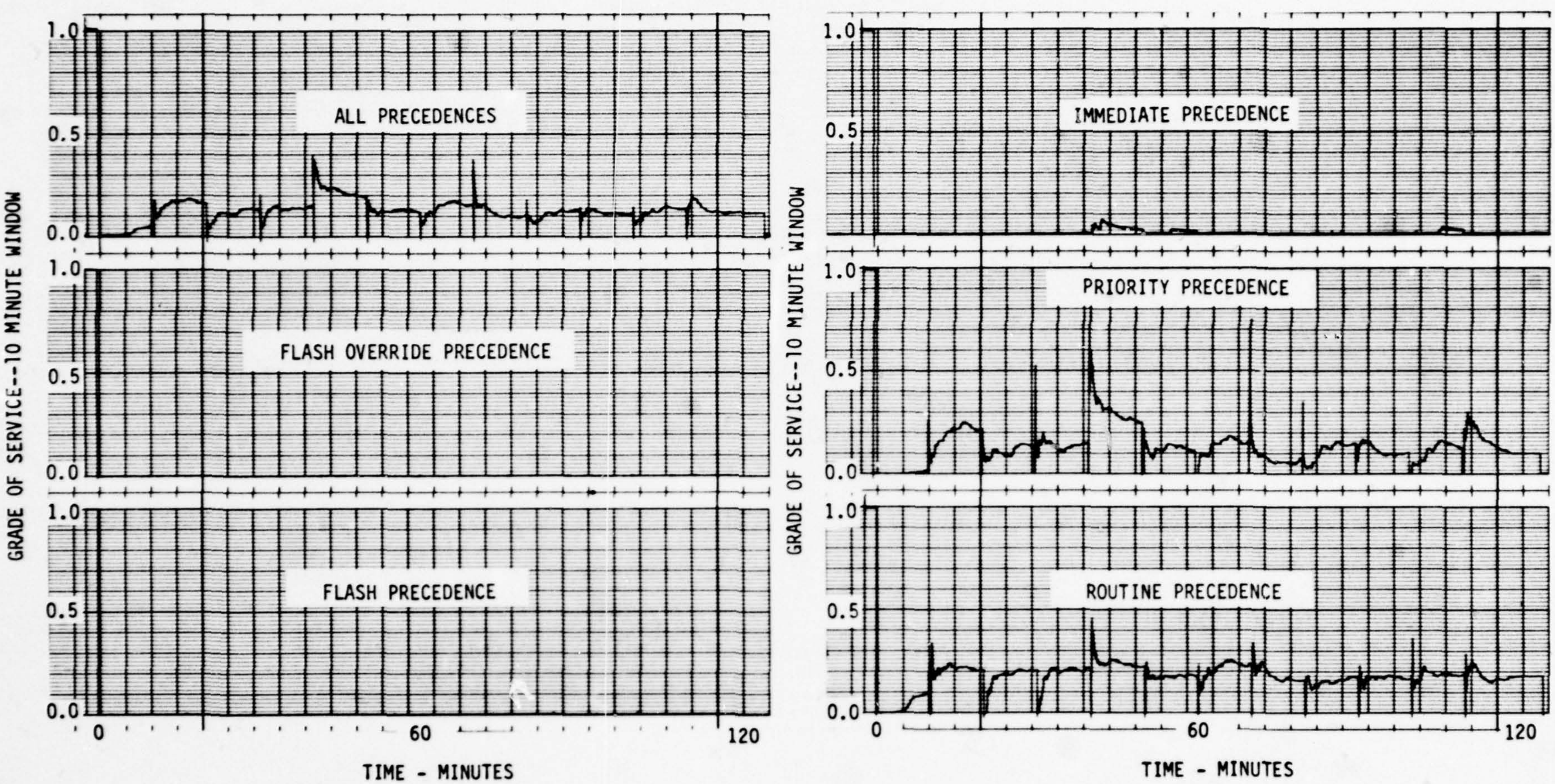
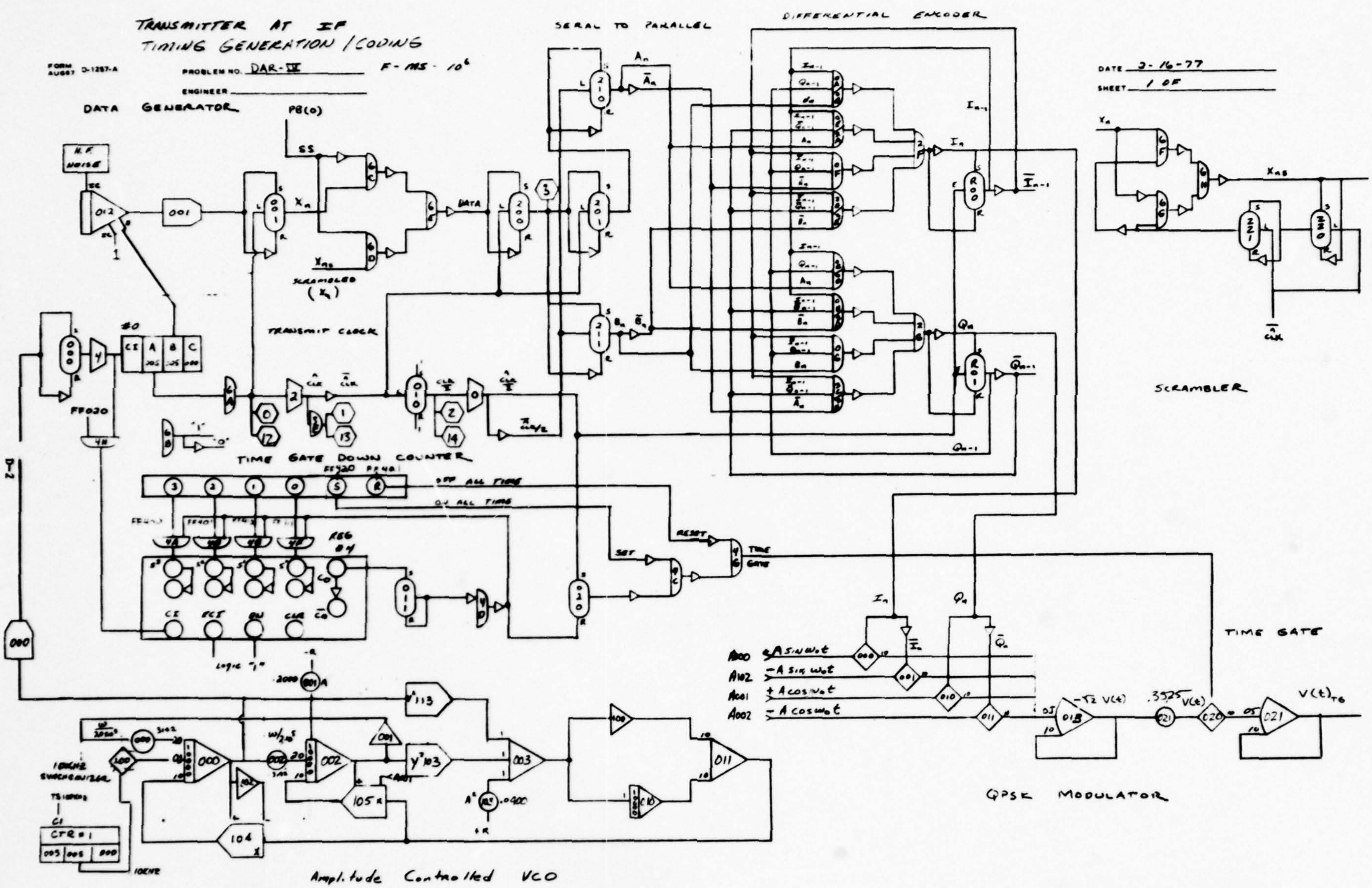


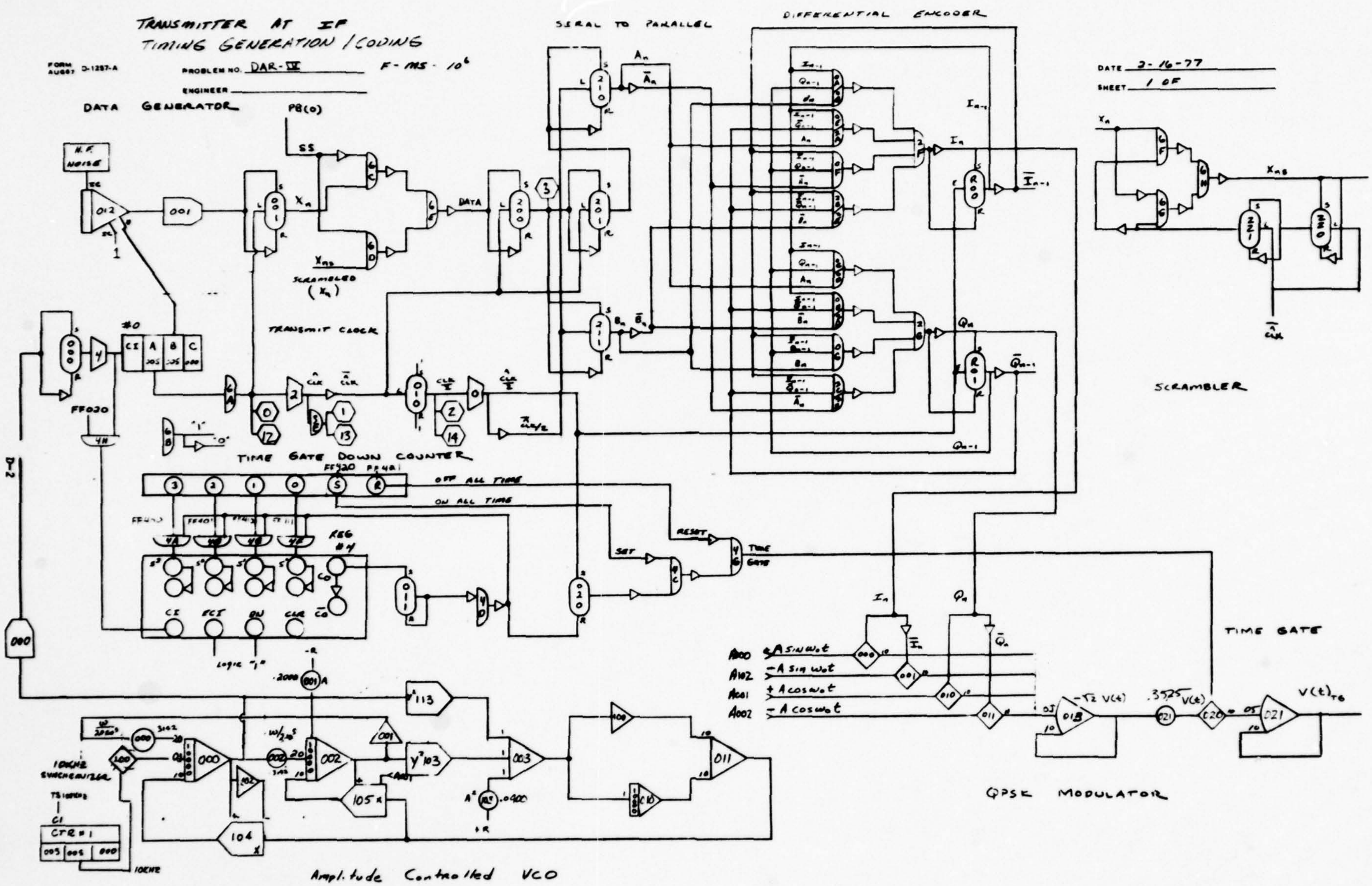
Figure C-2. (cont)

APPENDIX D

DAR ANALOG SIMULATION DIAGRAMS



TRANSMITTER AT IF
TIMING GENERATION / CODING
FORM AUG67 D-1257-A
PROBLEM NO. DAR-IV
F-MS-10^6
ENGINEER
DATE 2-16-77
SHEET 1 OF
DATA GENERATOR
H.F. NOISE
PB(0)
SS
DATA
SCRAMBLED (X_n)
TRANSMIT CLOCK
SERAL TO PARALLEL
DIFFERENTIAL ENCODER
SCRAMBLER
TIME GATE DOWN COUNTER
OFF ALL TIME
ON ALL TIME
RESET
SET
TIME GATE
Logic "1"
A00 +A sin w0t
A102 -A sin w0t
A001 +A cos w0t
A002 -A cos w0t
-√2 V(t)
.3535 V(t)
V(t)TG
QPSK MODULATOR
10KHZ SYNCHRONIZER
Amplitude Controlled VCO


TRANSMITTER AT IF
TIMING GENERATION / CODING
FORM AUG67 D-1257-A
PROBLEM NO. DAR-IV
F - MS - 10^6
ENGINEER
DATE 2-16-77
SHEET 1 OF
DATA GENERATOR
H.F. NOISE
PB(0)
SS
DATA
SCRAMBLED (X_n)
TRANSMIT CLOCK
SERIAL TO PARALLEL
DIFFERENTIAL ENCODER
SCRAMBLER
FF020
TIME GATE DOWN COUNTER
OFF ALL TIME
ON ALL TIME
REG #4
RESET
SET
TIME GATE
Logic "1"
TIME GATE
$+A \sin \omega_0 t$
$-A \sin \omega_0 t$
$+A \cos \omega_0 t$
$-A \cos \omega_0 t$
$-\sqrt{2}\, V(t)$
$.3535\, V(t)$
$V(t)_{TG}$
QPSK MODULATOR
10KHZ SYNCHRONIZER
CTR#1
Amplitude Controlled VCO

RF FILTER W/ NONLINEARITY

HYBRID COMPUTATIONS DEPARTMENT
ORLANDO DIVISION

FORM AUG67 D-1257-A

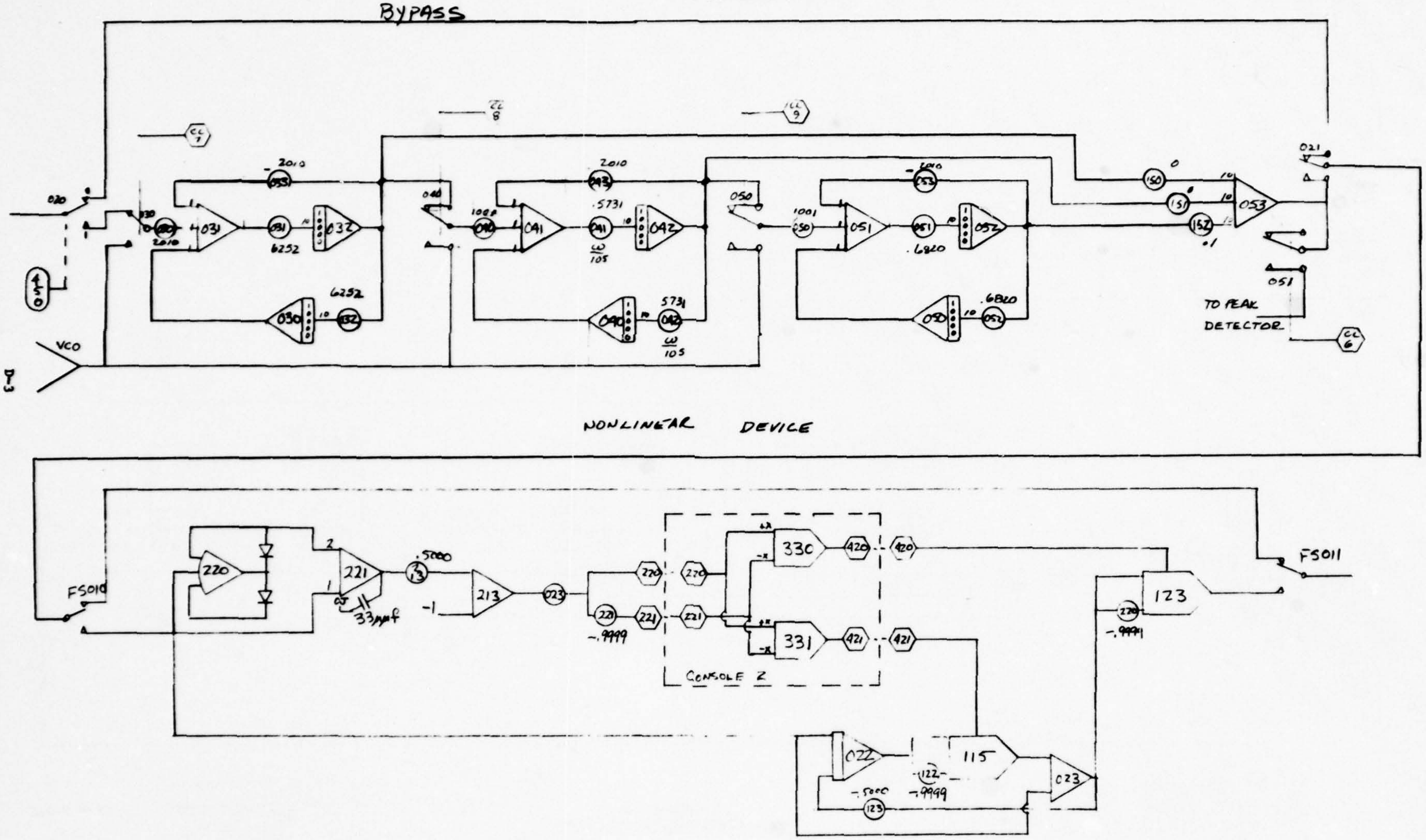
PROBLEM NO. DAR IV

ENGINEER

DATE

SHEET 2 OF

RF FILTER #1



RF FILTER #2

HYBRID COMPUTATIONS DEPARTMENT
ORLANDO DIVISION

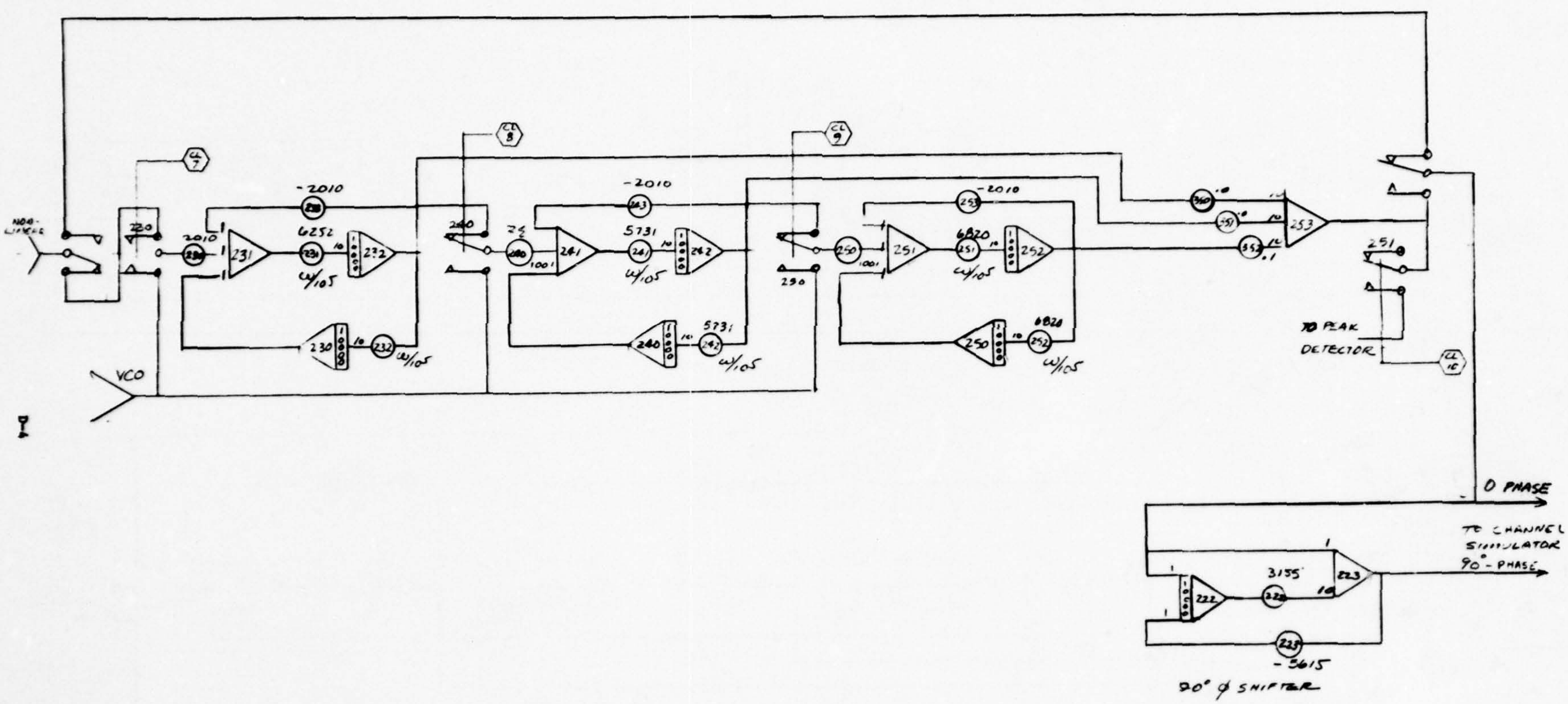
FORM D-1257-A AUG67

PROBLEM NO. DAR-IV

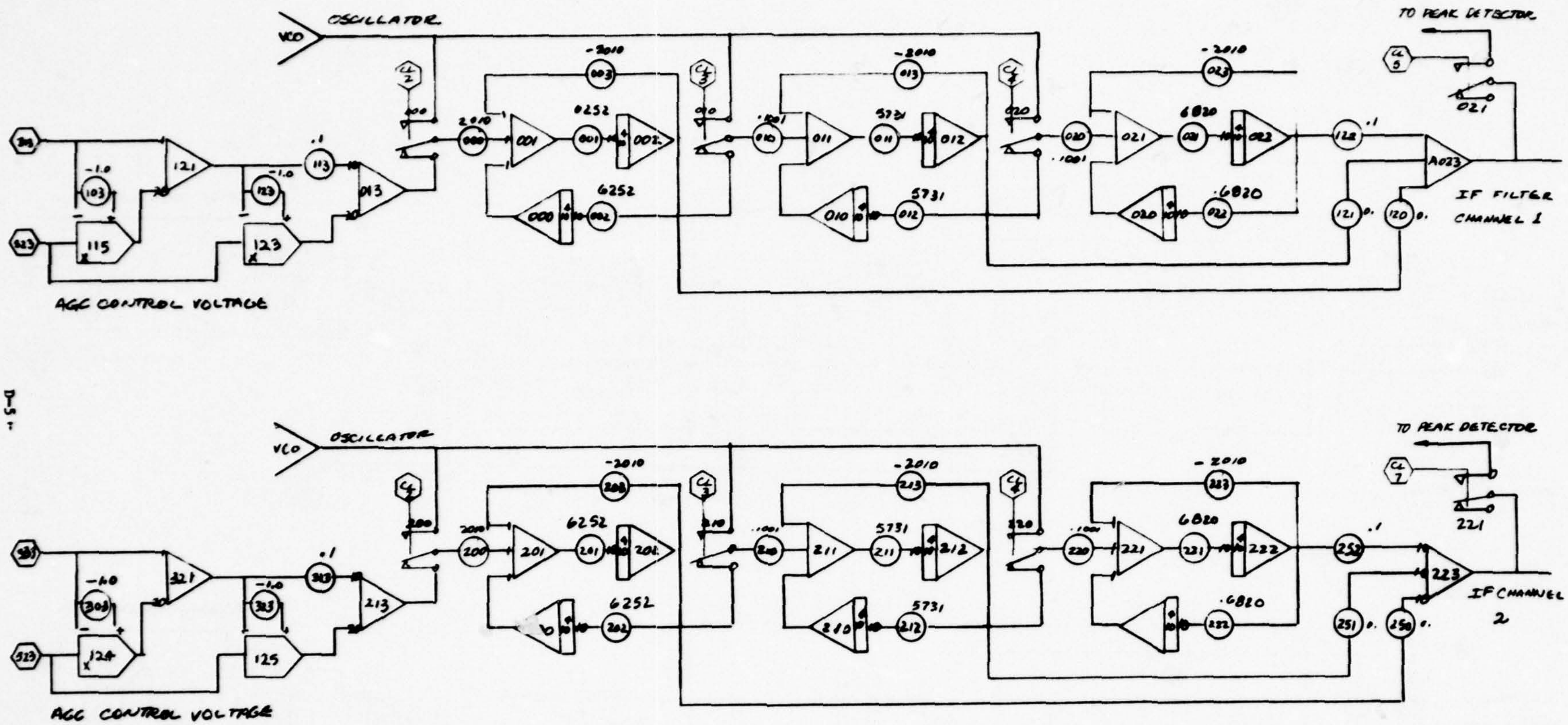
ENGINEER

DATE

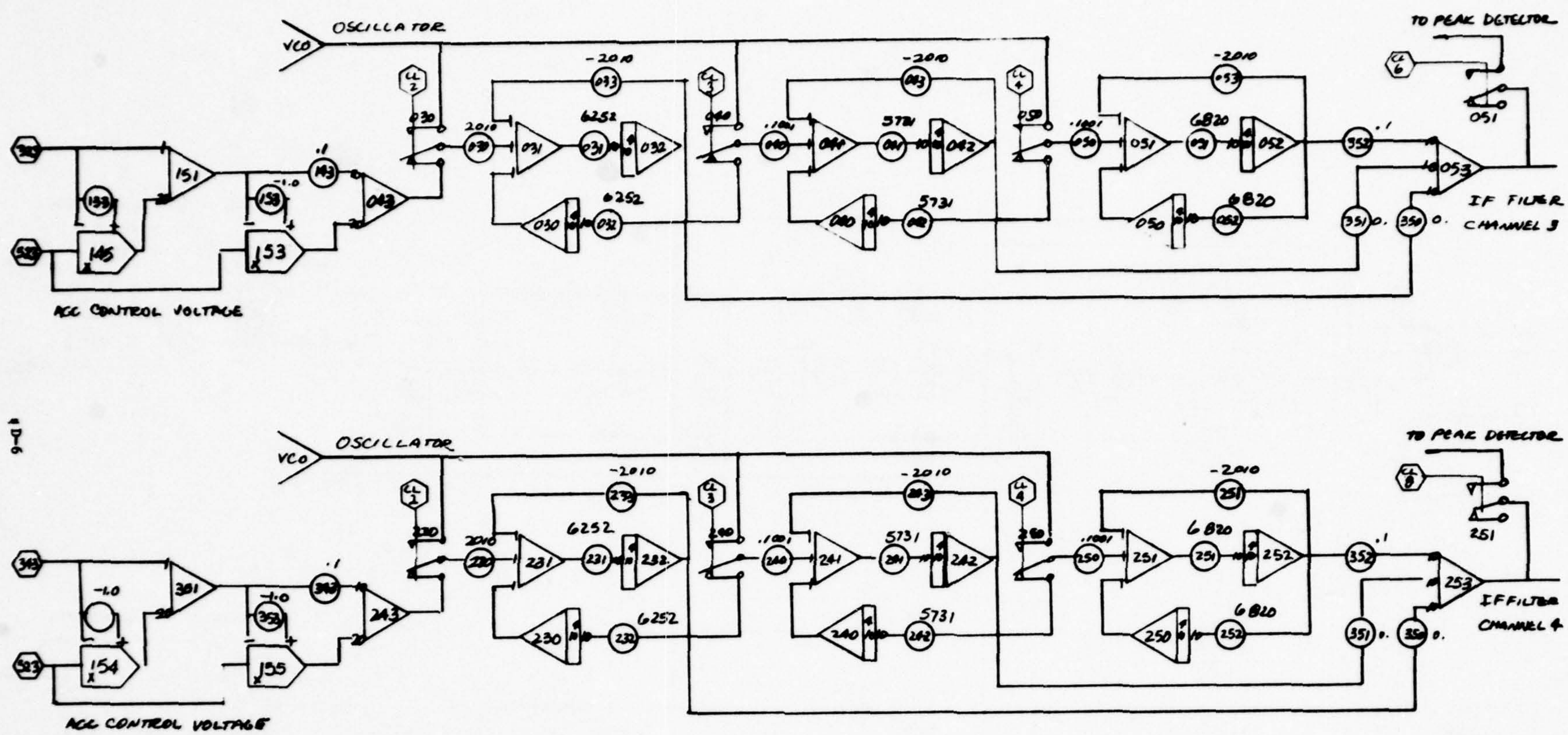
SHEET 3 OF



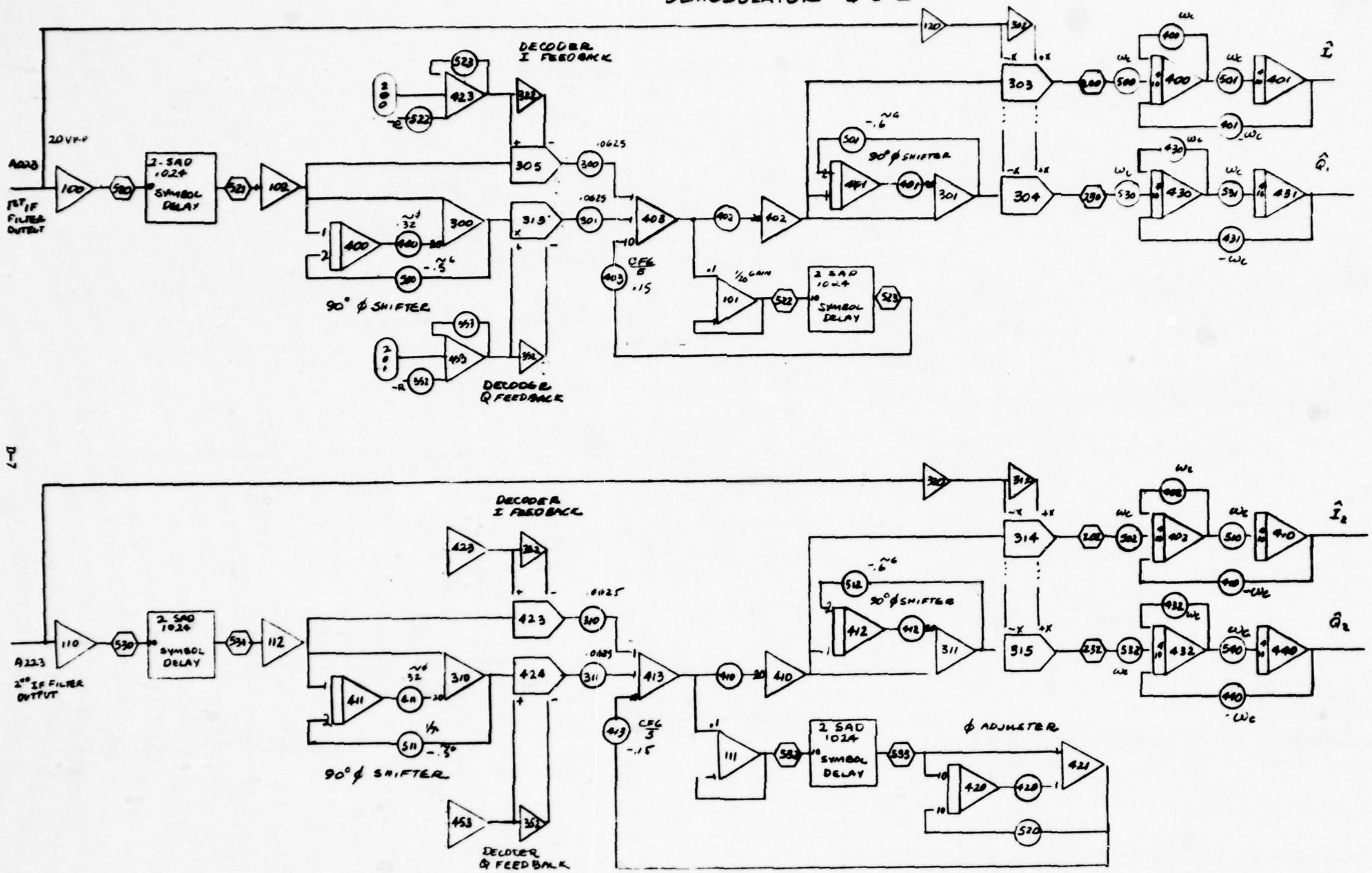
IF FILTERS 1 & 2 AND AGC



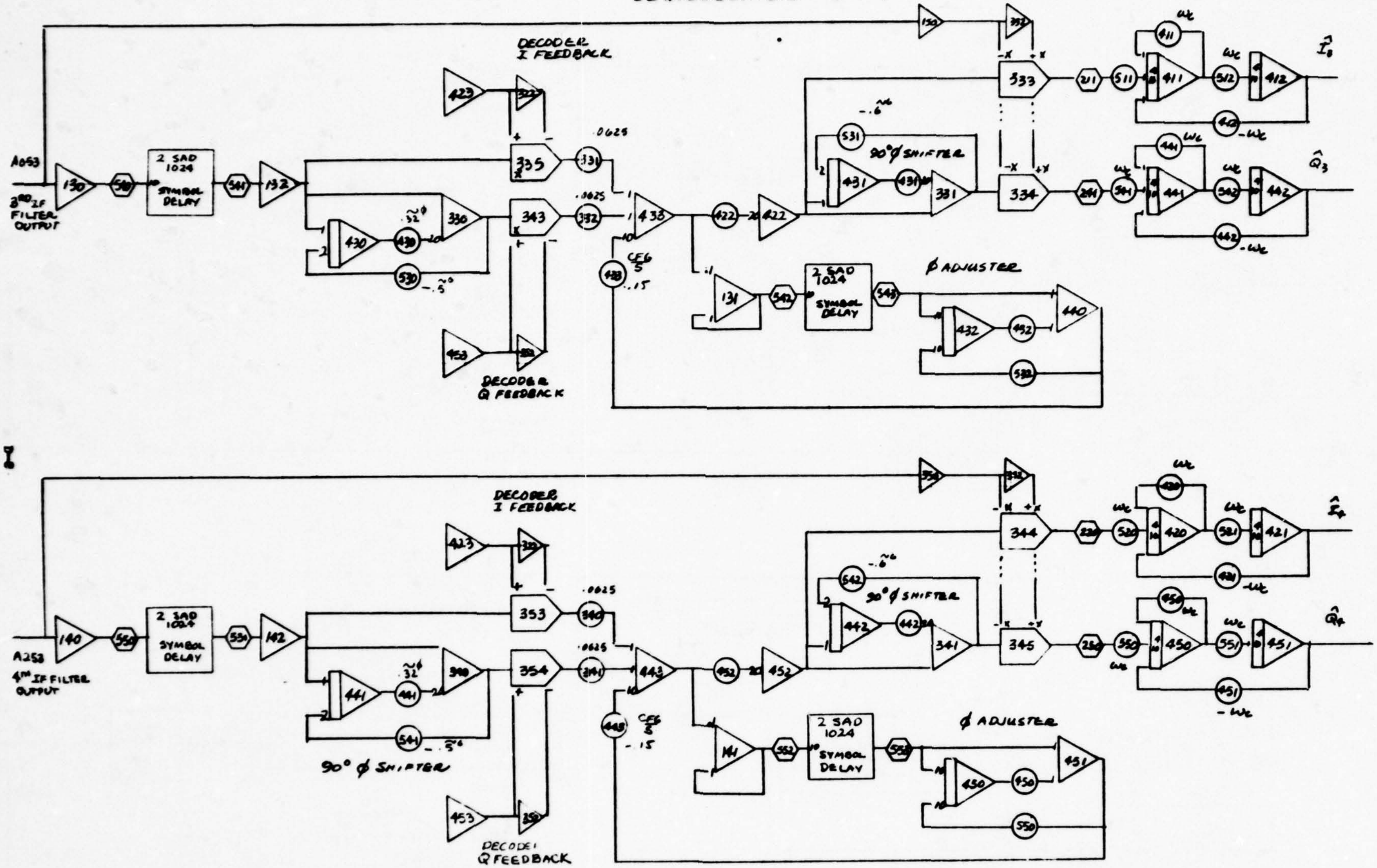
IF FILTERS 3 & 4 AND AGC



DEMODULATOR 1 & 2



DEMODULATOR 3 & 4



VIDEO SUMMER / INTEGRATE & DUMP / DECODING

HYBRID COMPUTATIONS DEPARTMENT

ORLANDO DIVISION

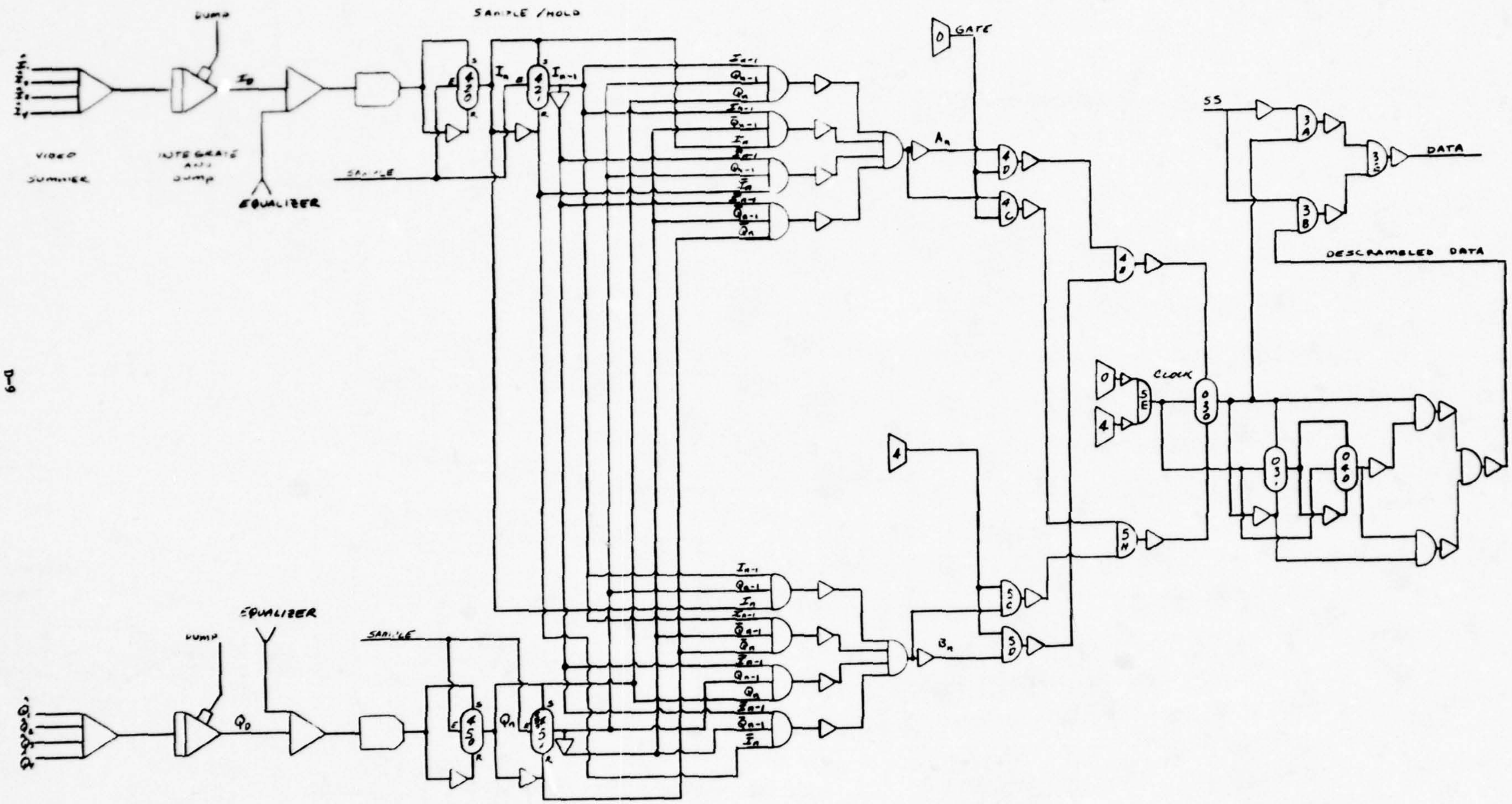
FORM D-1257-A

PROBLEM NO. DAR IV

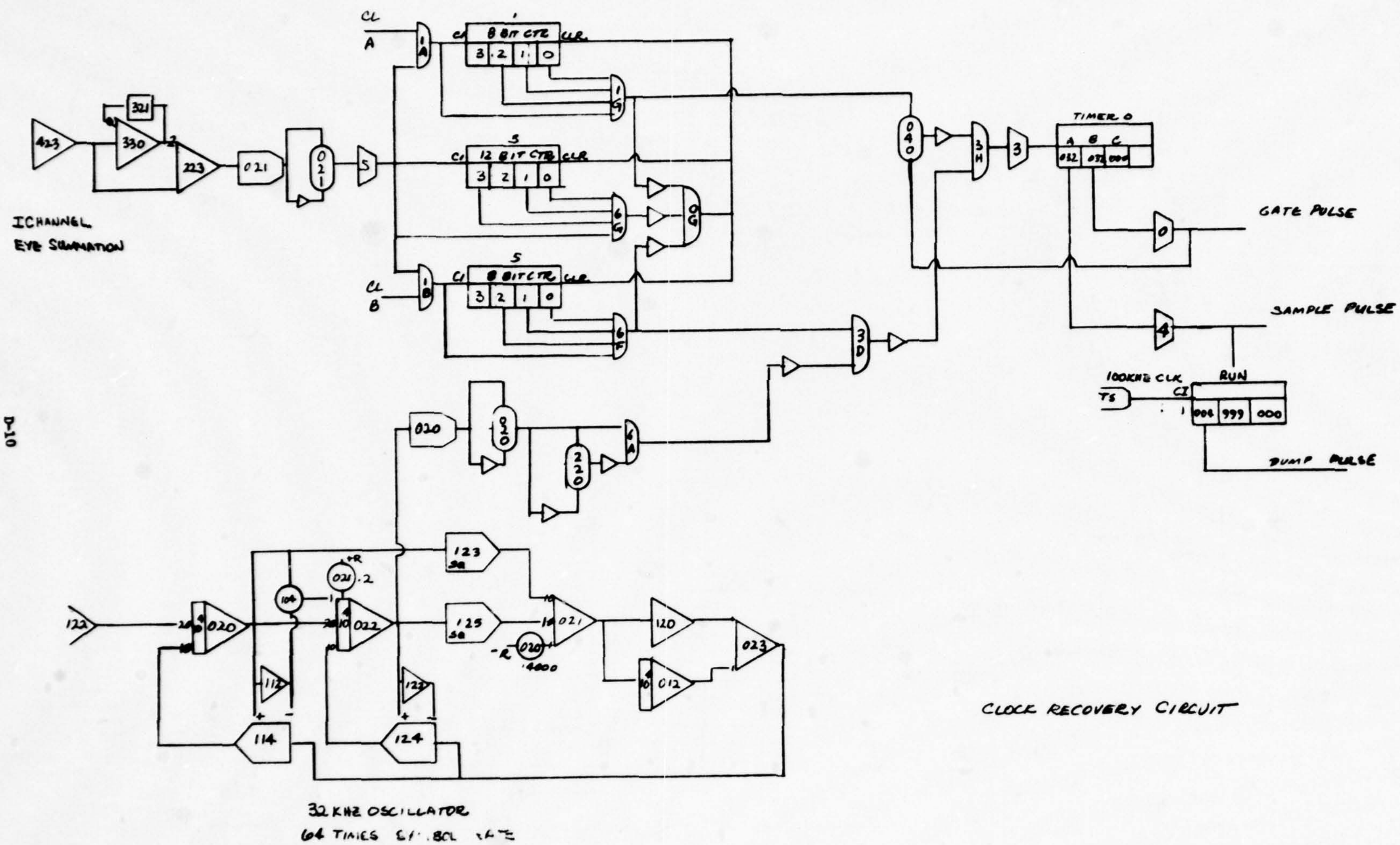
ENGINEER

DATE

SHEET 8 OF



BIT TIMING RECOVERY



APPENDIX E

QPR/QPSK ANALOG SIMULATION DIAGRAMS

FORM D-1257-A AUG67

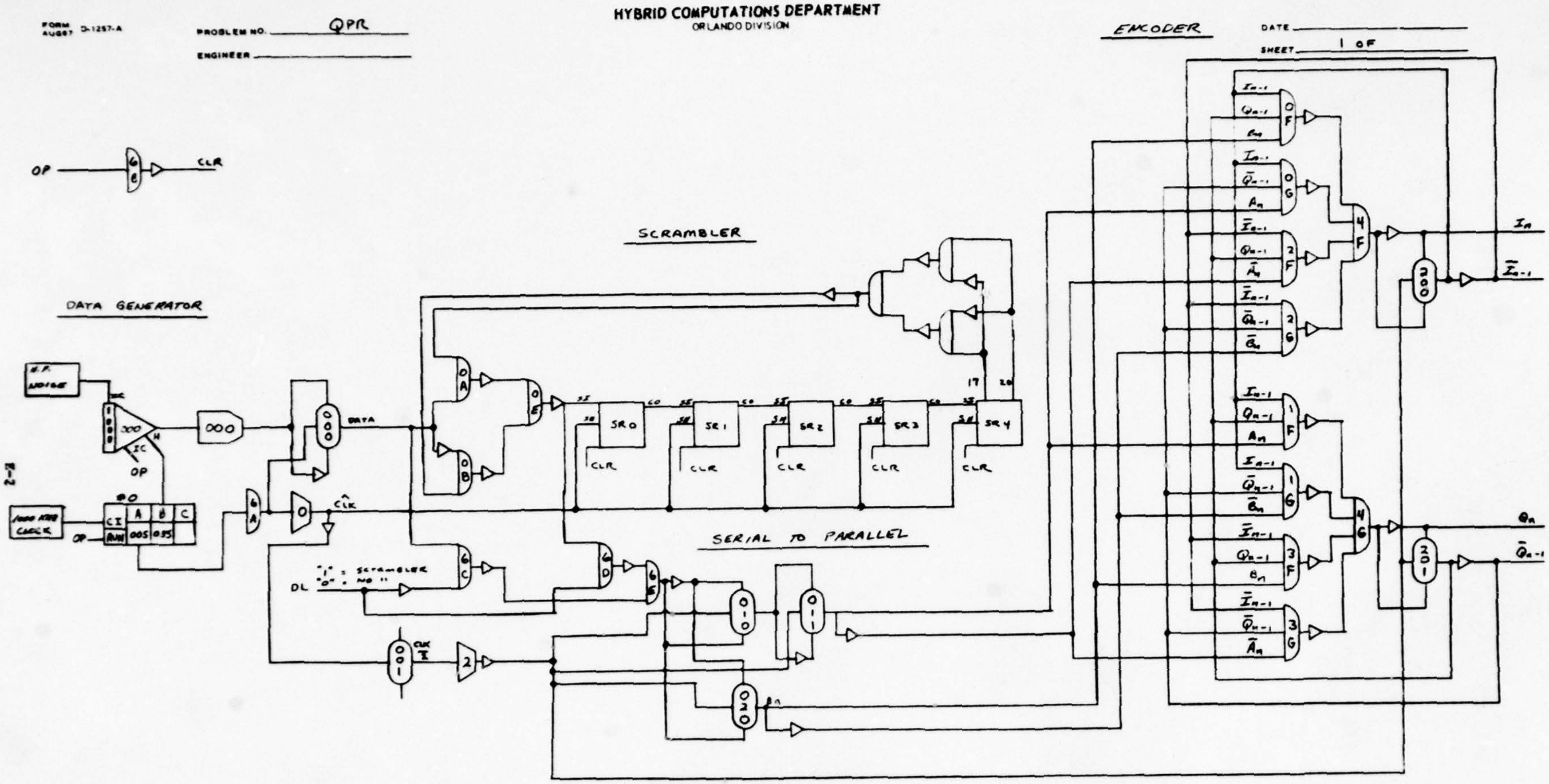
PROBLEM NO. QPR

ENGINEER

HYBRID COMPUTATIONS DEPARTMENT
ORLANDO DIVISION

DATE

SHEET 1 OF



FORM D-1257-A AUG 67

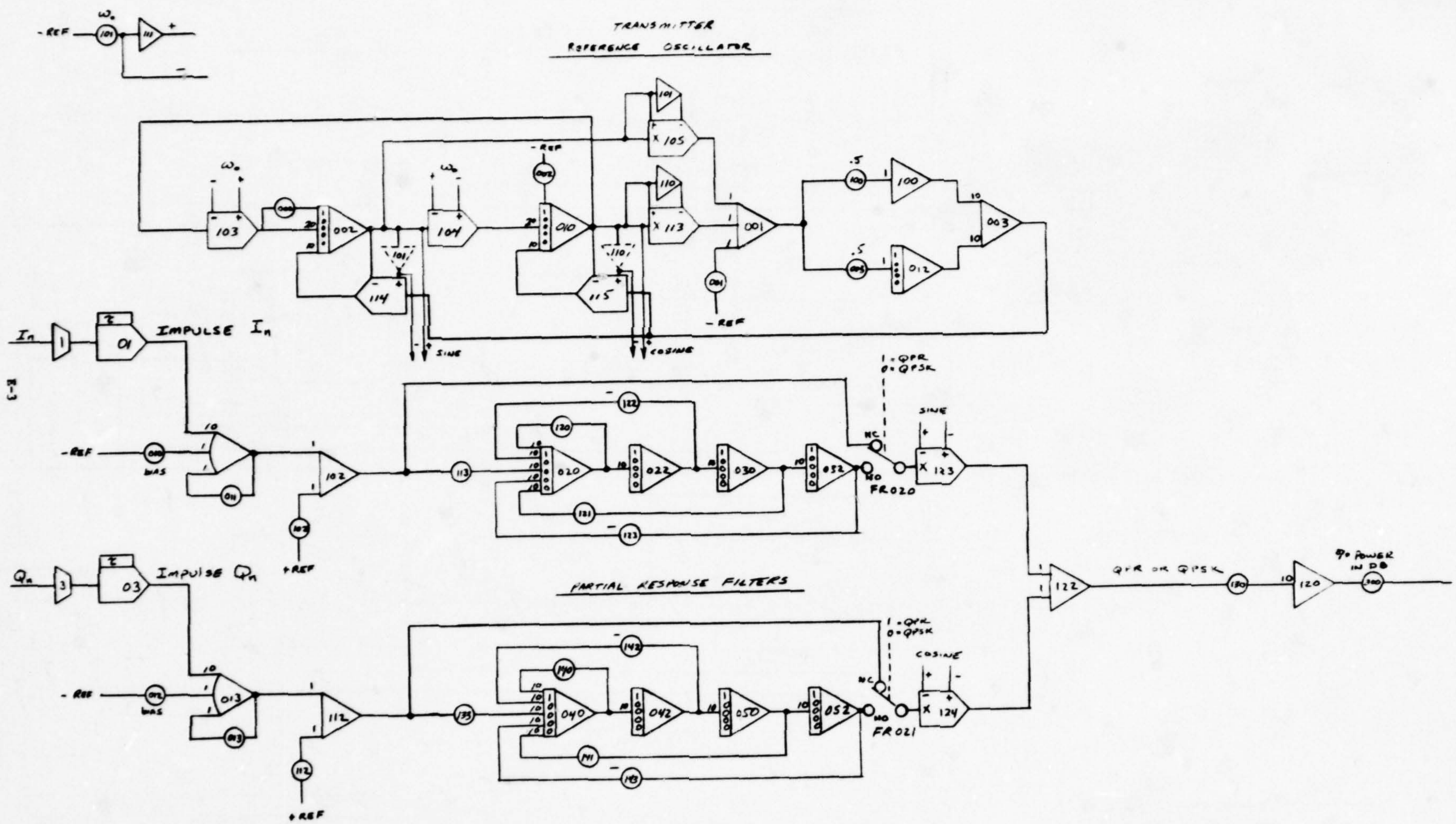
PROBLEM NO. QPR

ENGINEER

HYBRID COMPUTATIONS DEPARTMENT
ORLANDO DIVISION

DATE

SHEET 2 OF



FORM D-1257-A AUG67

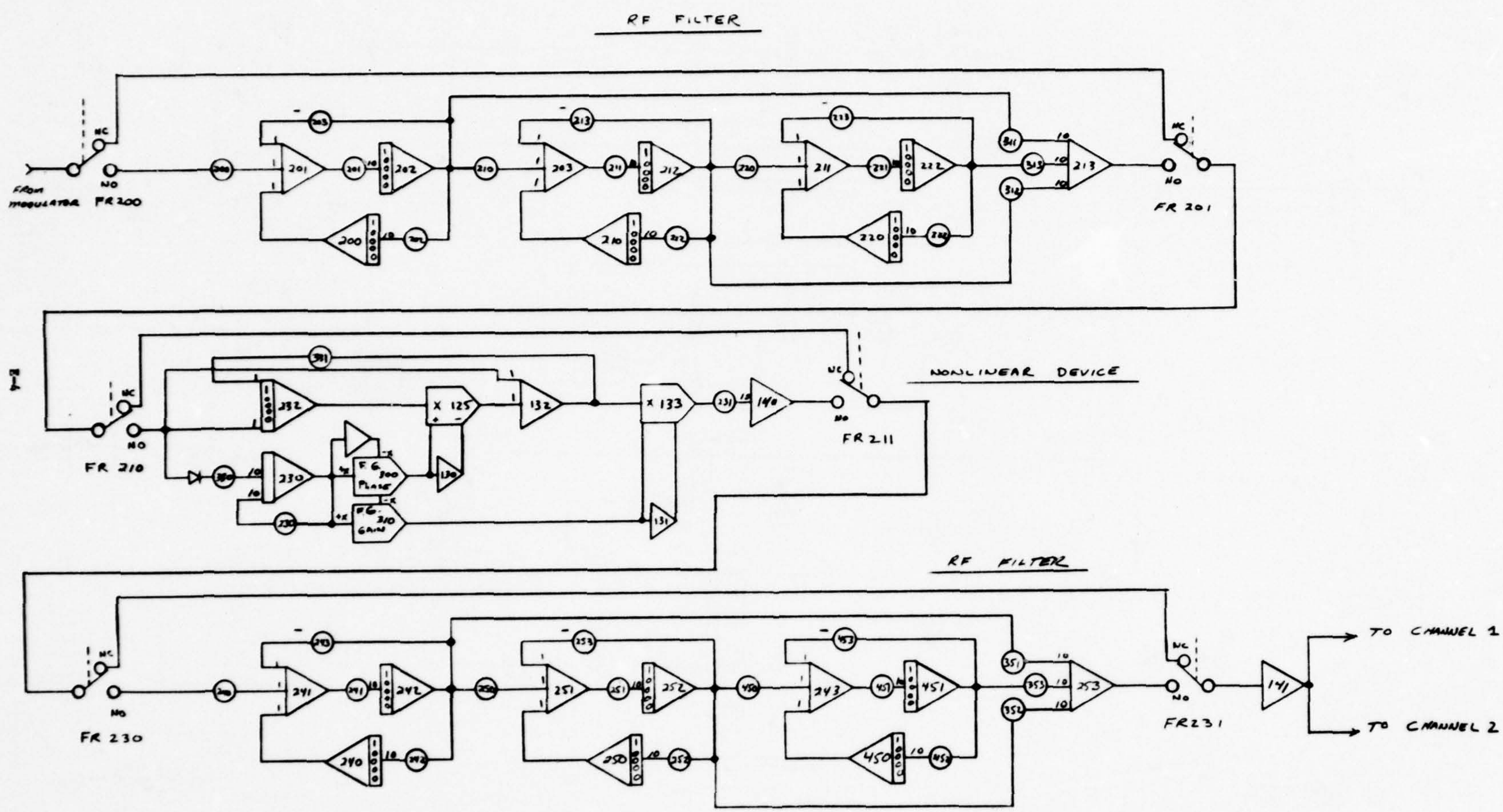
PROBLEM NO. QPR

ENGINEER

HYBRID COMPUTATIONS DEPARTMENT
ORLANDO DIVISION

DATE

SHEET 3 OF



FORM D-1257-A
AUGST

PROBLEM NO. QPR

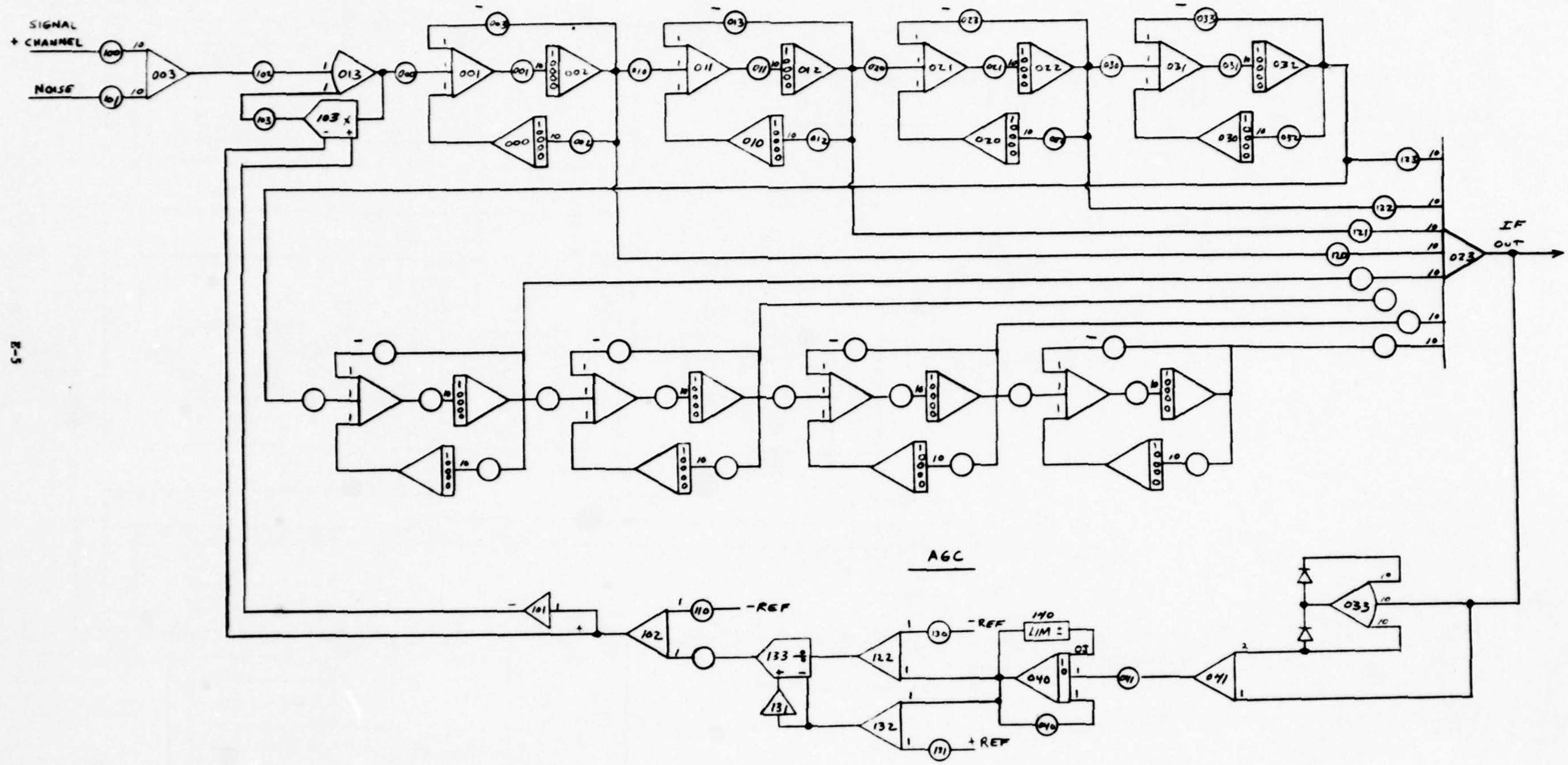
ENGINEER

HYBRID COMPUTATIONS DEPARTMENT
ORLANDO DIVISION

DATE

SHEET 4 OF

IF FILTER



FORM D-1257-A AUG67

HYBRID COMPUTATIONS DEPARTMENT
ORLANDO DIVISION

PROBLEM NO. QPR

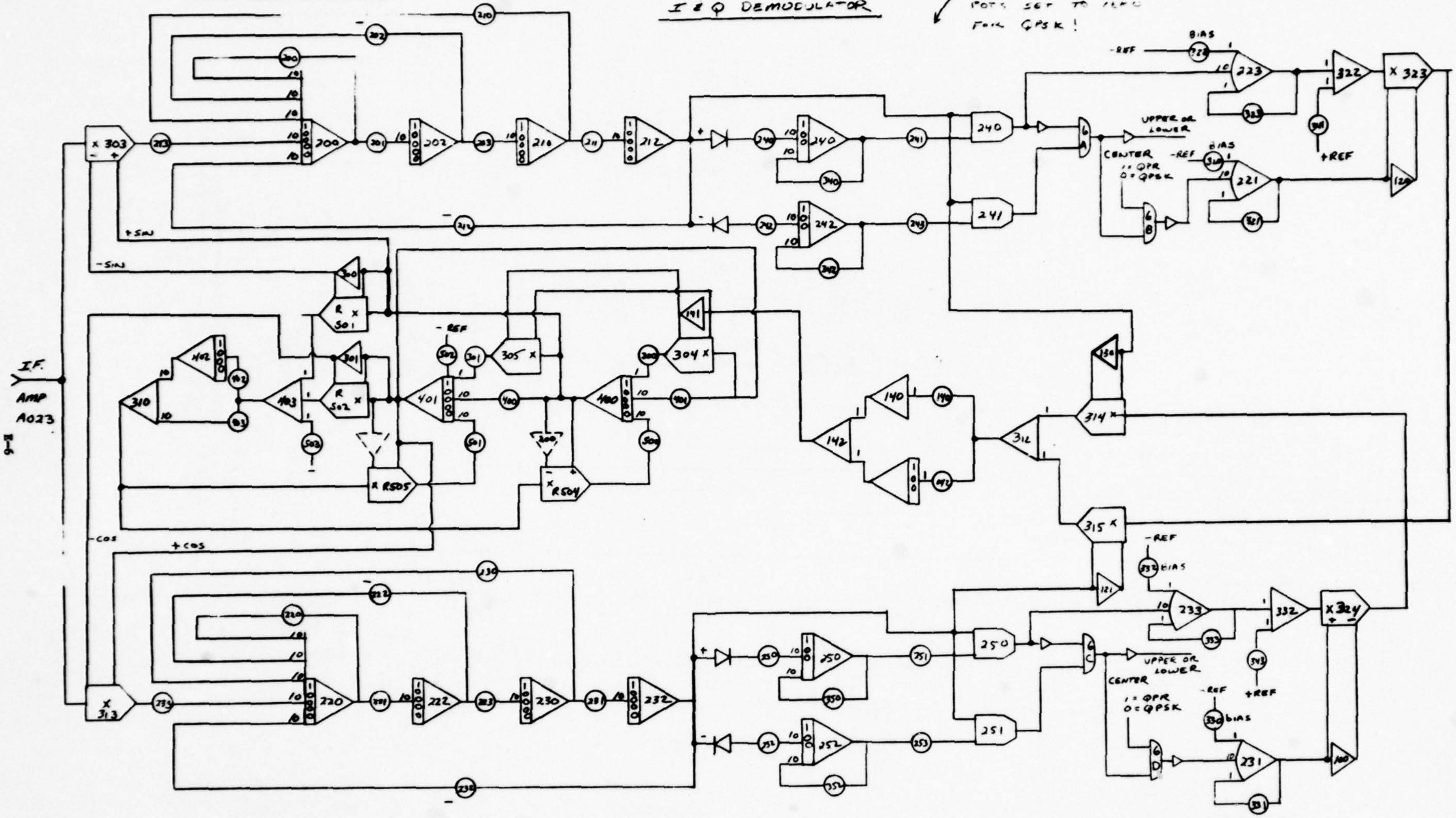
ENGINEER

DATE

SHEET 5 OF

I & Q DEMODULATOR

All COMPARATOR POTS SET TO ZERO FOR QPSK!



FORM D-1257-A AUG 67

PROBLEM NO. QPR

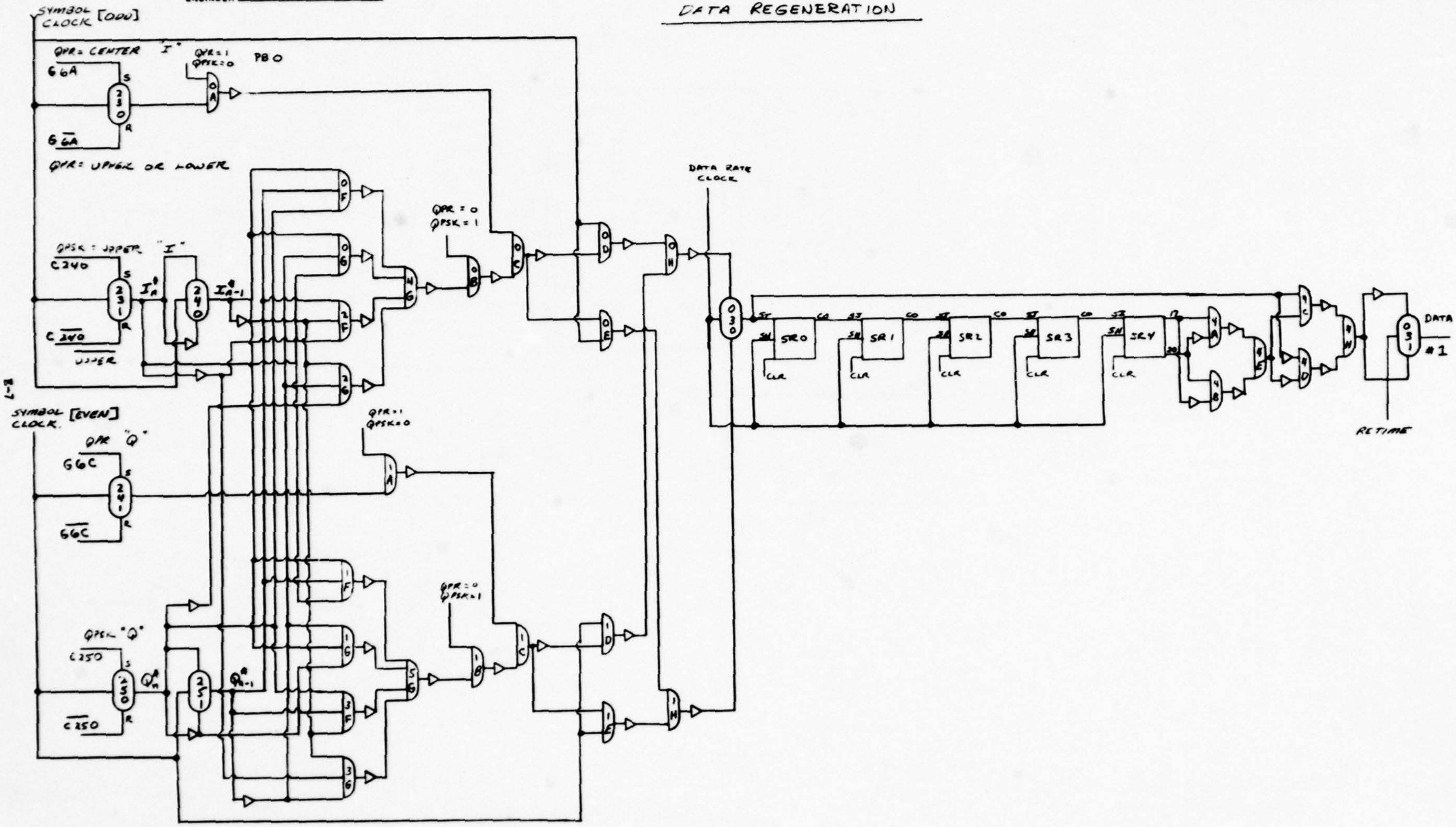
ENGINEER

HYBRID COMPUTATIONS DEPARTMENT
ORLANDO DIVISION

DATE

SHEET 6

DATA REGENERATION



FORM AUG67 D-1257-A

PROBLEM NO. MDC

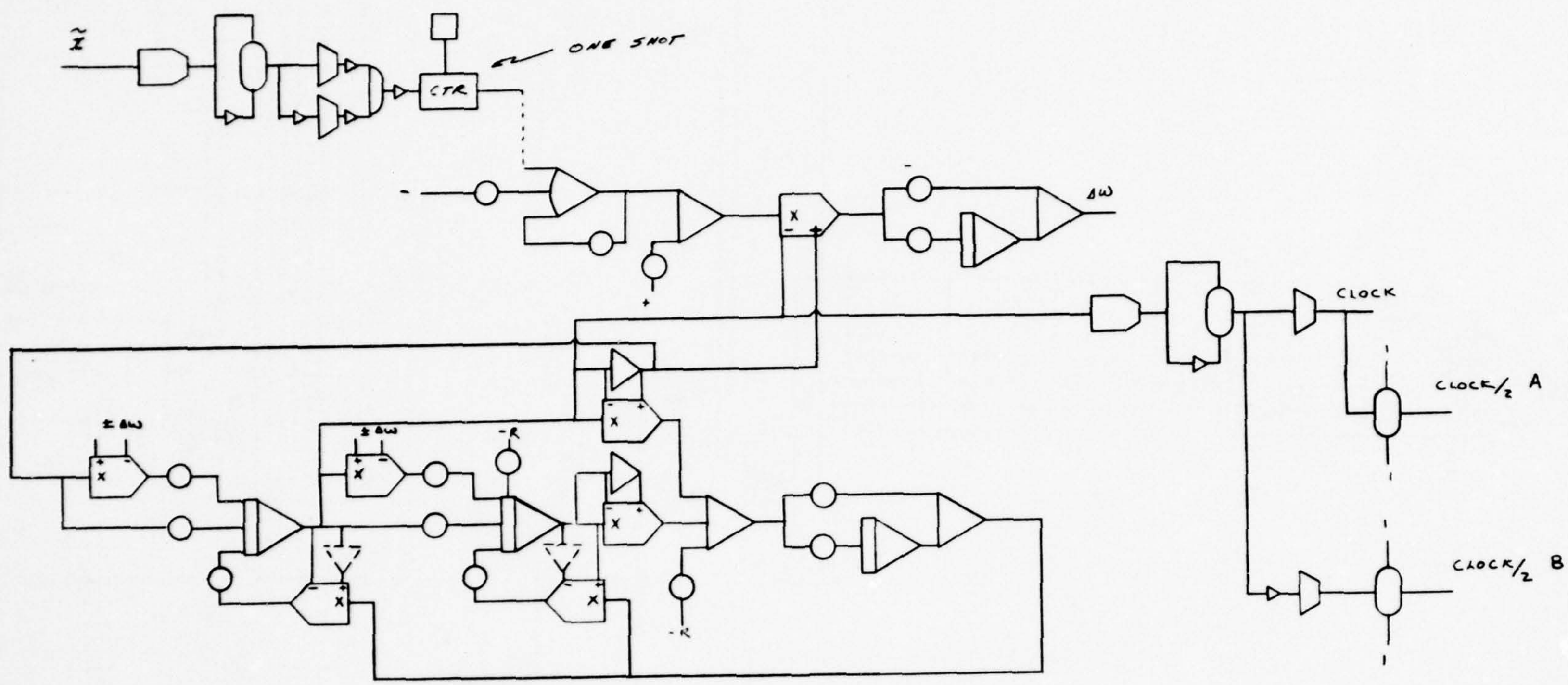
ENGINEER

HYBRID COMPUTATIONS DEPARTMENT
ORLANDO DIVISION

DATE

SHEET 7

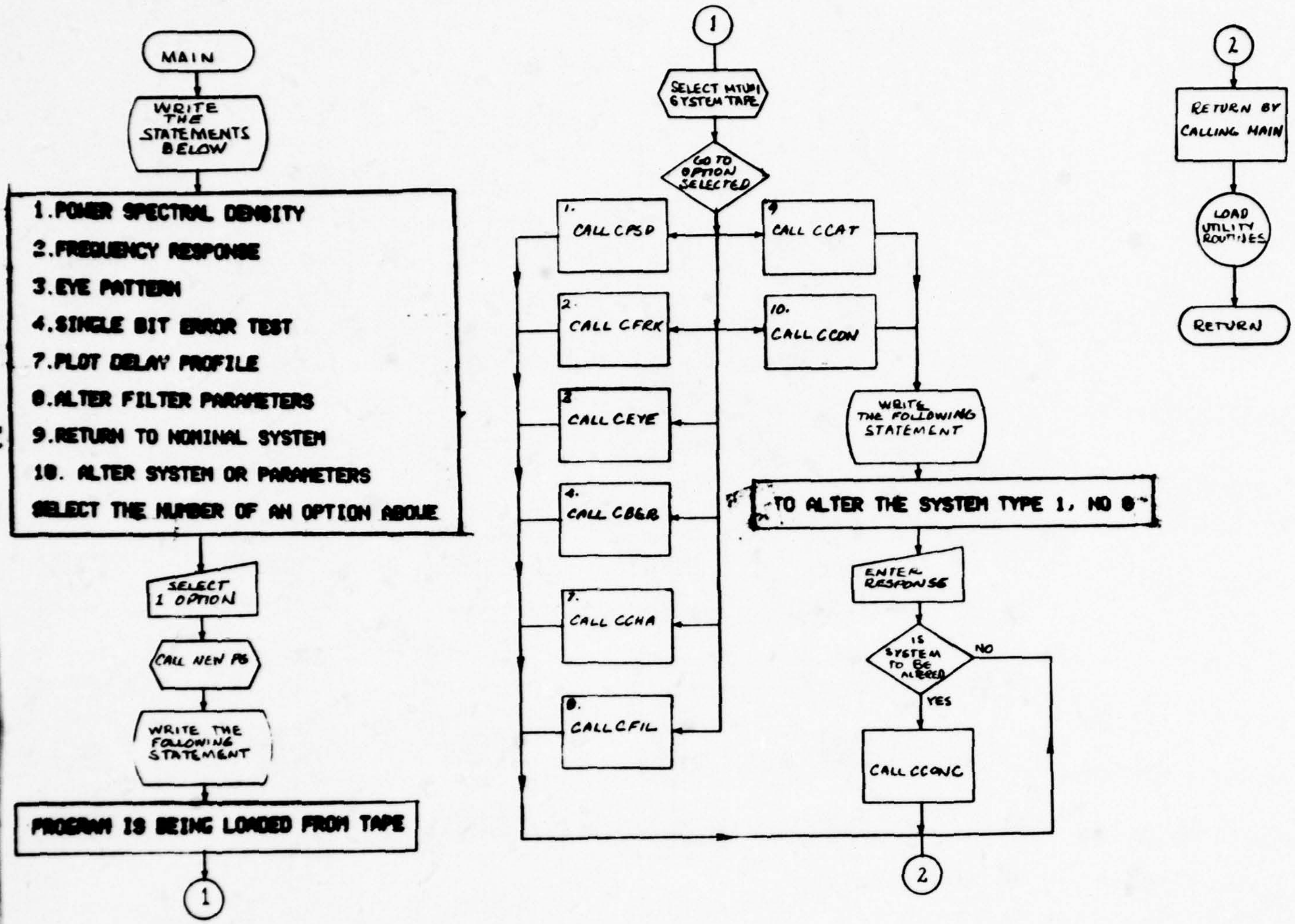
CLOCK RECOVERY

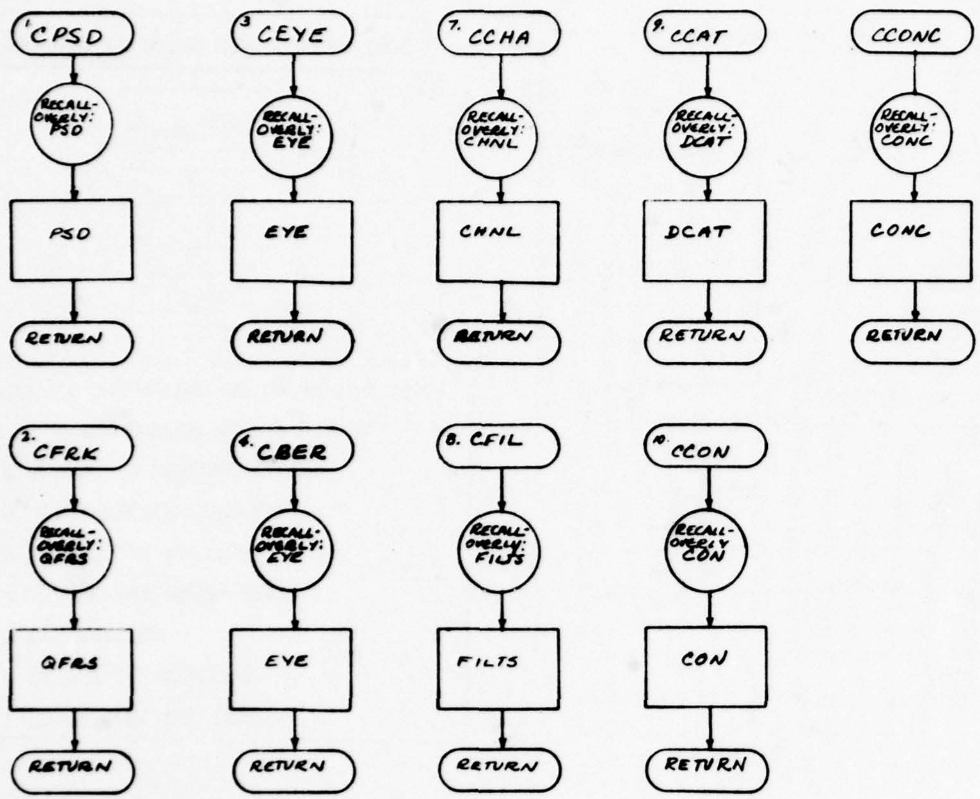


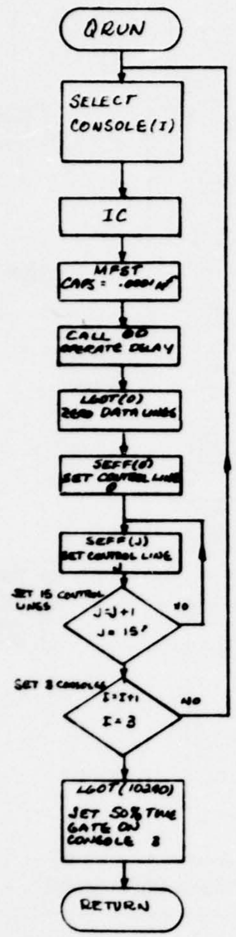
BIT RATE CLOCK

APPENDIX F

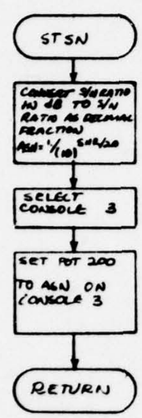
SUPPORTIVE SOFTWARE FUNCTIONAL FLOW BLOCK DIAGRAMS

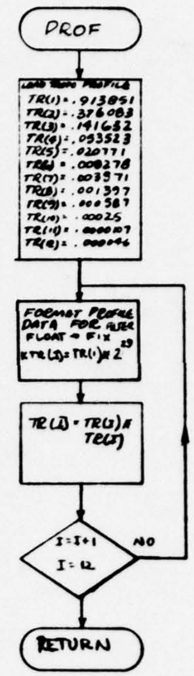

MAIN
WRITE THE STATEMENTS BELOW
1.POWER SPECTRAL DENSITY
2.FREQUENCY RESPONSE
3.EYE PATTERN
4.SINGLE BIT ERROR TEST
7.PLOT DELAY PROFILE
8.ALTER FILTER PARAMETERS
9.RETURN TO NOMINAL SYSTEM
10. ALTER SYSTEM OR PARAMETERS
SELECT THE NUMBER OF AN OPTION ABOVE
SELECT 1 OPTION
CALL NEW PG
WRITE THE FOLLOWING STATEMENT
PROGRAM IS BEING LOADED FROM TAPE
1
1
SELECT MTU1 6YSTEM TAPE
GO TO OPTION SELECTED
1. CALL CPSD
2. CALL CFRK
3 CALL CEYE
4. CALL CBER
7. CALL CCHA
8. CALL CFIL
9 CALL CCAT
10. CALL CCON
WRITE THE FOLLOWING STATEMENT
"TO ALTER THE SYSTEM TYPE 1, NO 0"
ENTER RESPONSE
IS SYSTEM TO BE ALTERED
NO
YES
CALL CCONC
2
2
RETURN BY CALLING MAIN
LOAD UTILITY ROUTINES
RETURN

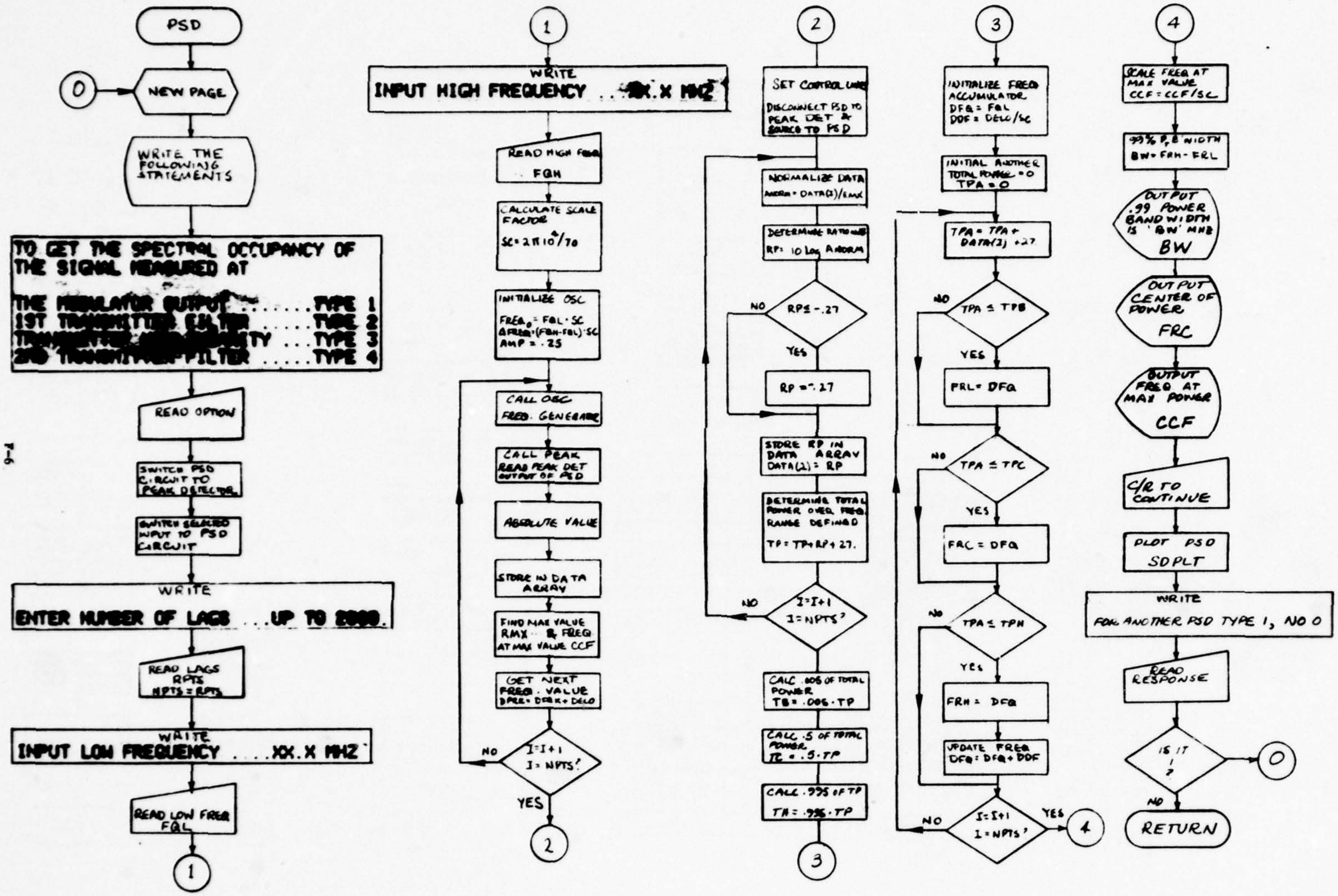

1. CPSD
RECALL-OVERLY: PSD
PSD
RETURN
3 CEYE
RECALL-OVERLY: EYE
EYE
RETURN
7. CCHA
RECALL-OVERLY: CHNL
CHNL
RETURN
9. CCAT
RECALL-OVERLY: DCAT
DCAT
RETURN
CCONC
RECALL-OVERLY: CONC
CONC
RETURN
2. CFRK
RECALL-OVERLY: QFRS
QFRS
RETURN
4. CBER
RECALL-OVERLY: EYE
EYE
RETURN
8. CFIL
RECALL-OVERLY: FILTS
FILTS
RETURN
10. CCON
RECALL-OVERLY CON
CON
RETURN

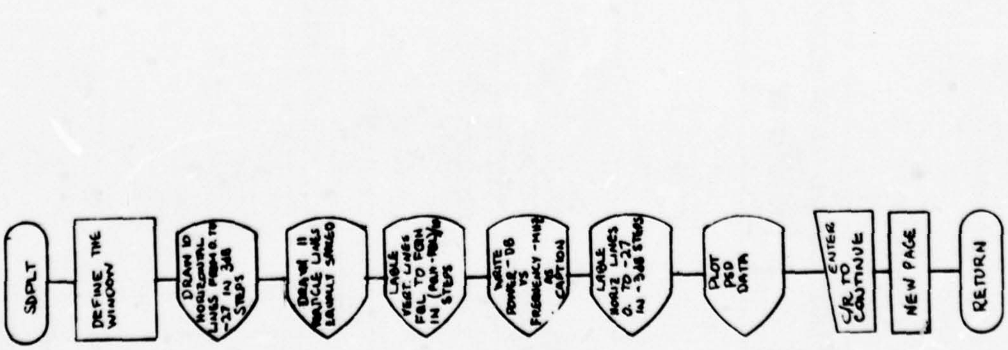


CL No	CONSOLE 1		CONSOLE 2		CONSOLE 3	
0	PSD CIRCUIT	OUT	AGC	OUT		
1	PSD INPUT MODULATOR	OUT		IN	1ST RF FILTER	IN
2	PSD INPUT 1ST RF FILTER	OUT	OSC INPUT TO 1ST IF FILTERS	NO	2ND RF FILTER	IN
3	PSD INPUT NON-LINEARITY	OUT	OSC INPUT TO 2ND IF FILTERS	NO	PEAK DETECTOR CONTROL	IC
4	PSD INPUT 2ND RF FILTER	OUT	OSC INPUT TO 3RD IF FILTERS	NO	NON LINEARITY	OUT
5			1ST IF FILT SW TO PEAK DET	NO	CHANNEL	OUT
6			2ND IF FILT SW TO PEAK DET	NO	1ST RF FILTER SW TO PEAK DET	NO
7			3RD IF FILT SW TO PEAK DET	NO	OSC INPUT TO 1ST RF FILTS	NO
8			4TH IF FILT SW TO PEAK DET	NO	OSC INPUT TO 2ND RF FILTS	NO
9					OSC INPUT TO 3RD RF FILTS	NO
10					2ND RF FILTER SW TO PEAK DET	NO
11					OSCILLATOR INT. RATE CONT.	
12					OSCILLATOR INT. GATE CONT.	
13					OSCILLATOR INT. GATE CONT.	
14					SCRAMBLER	OUT
15						

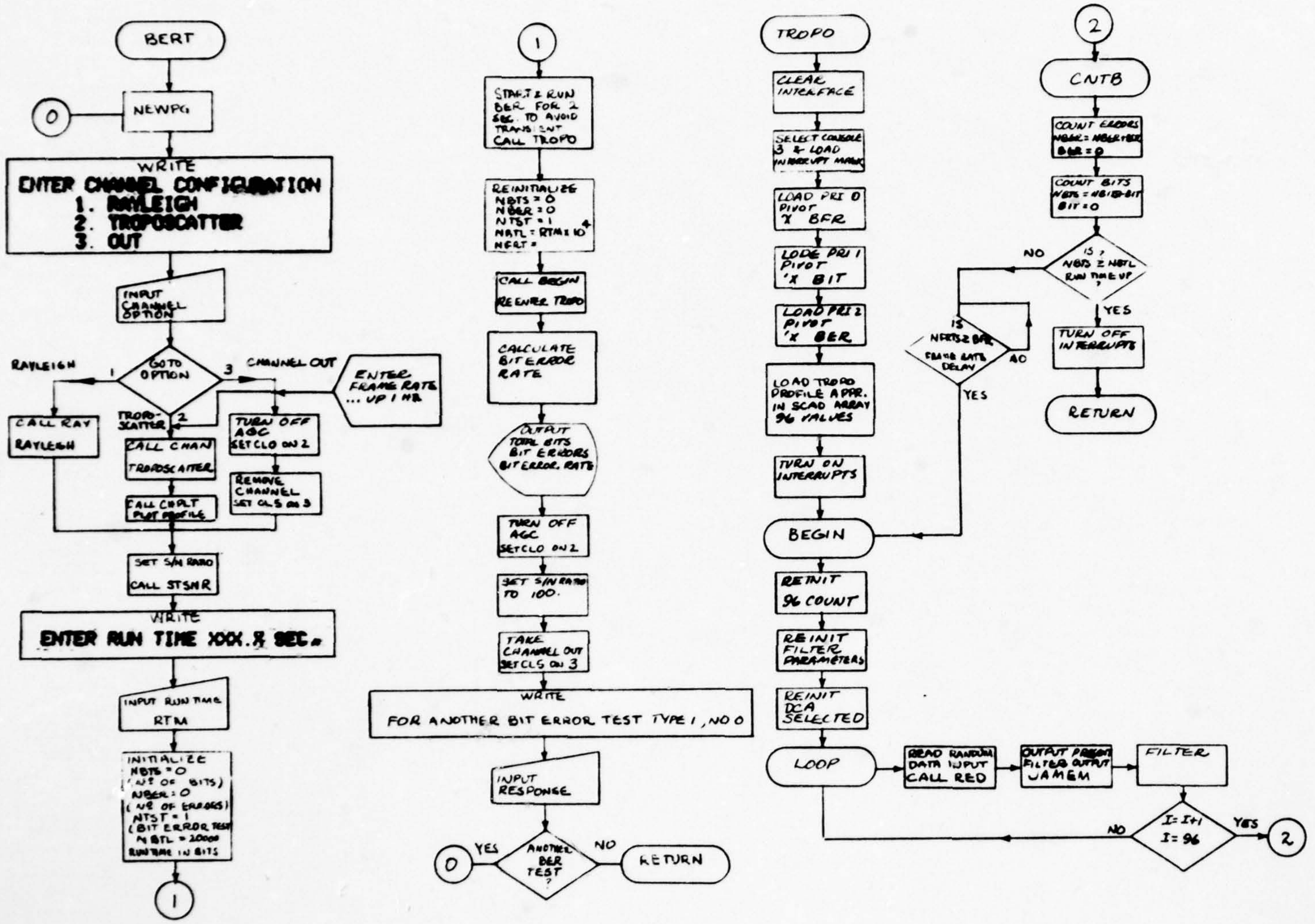


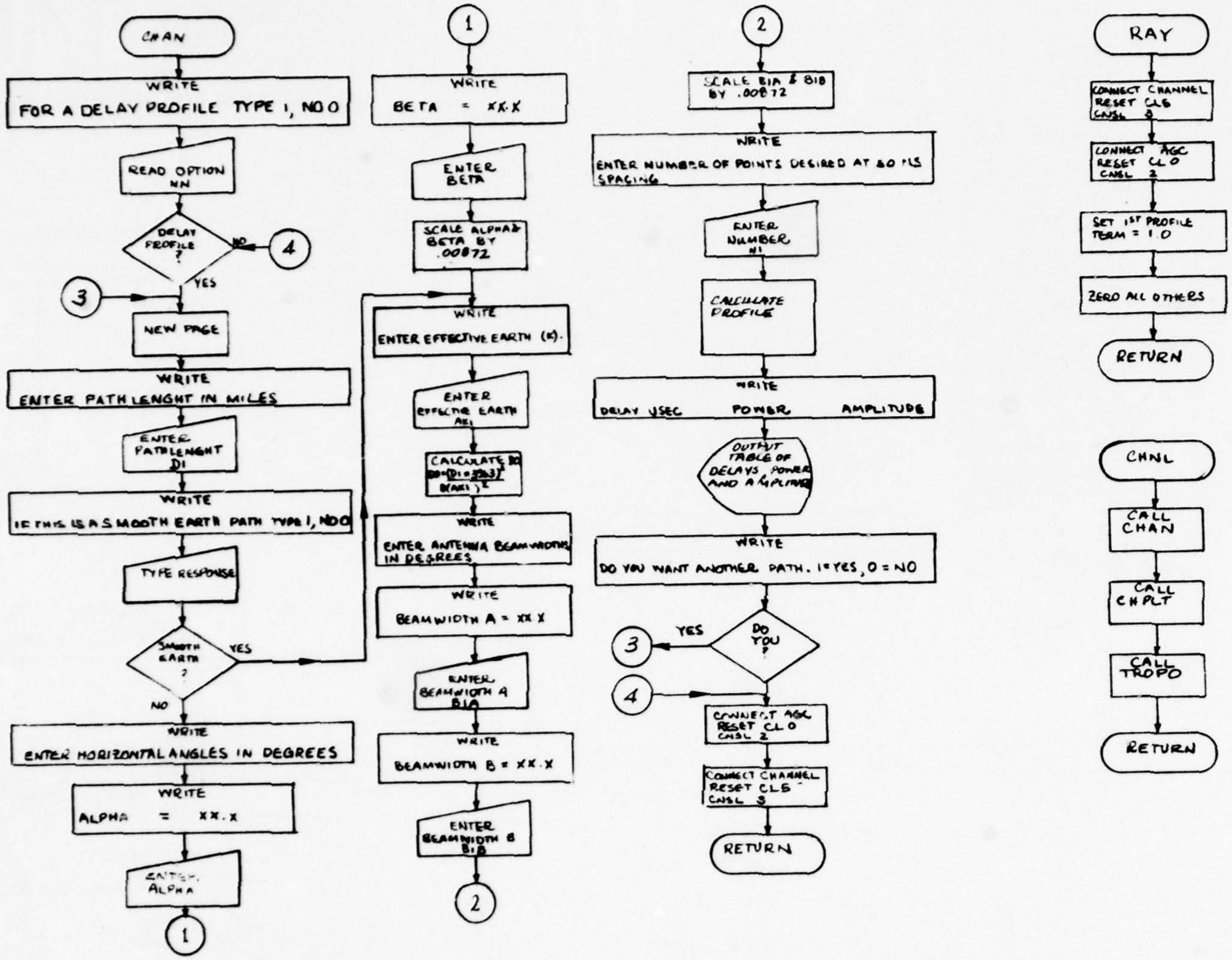


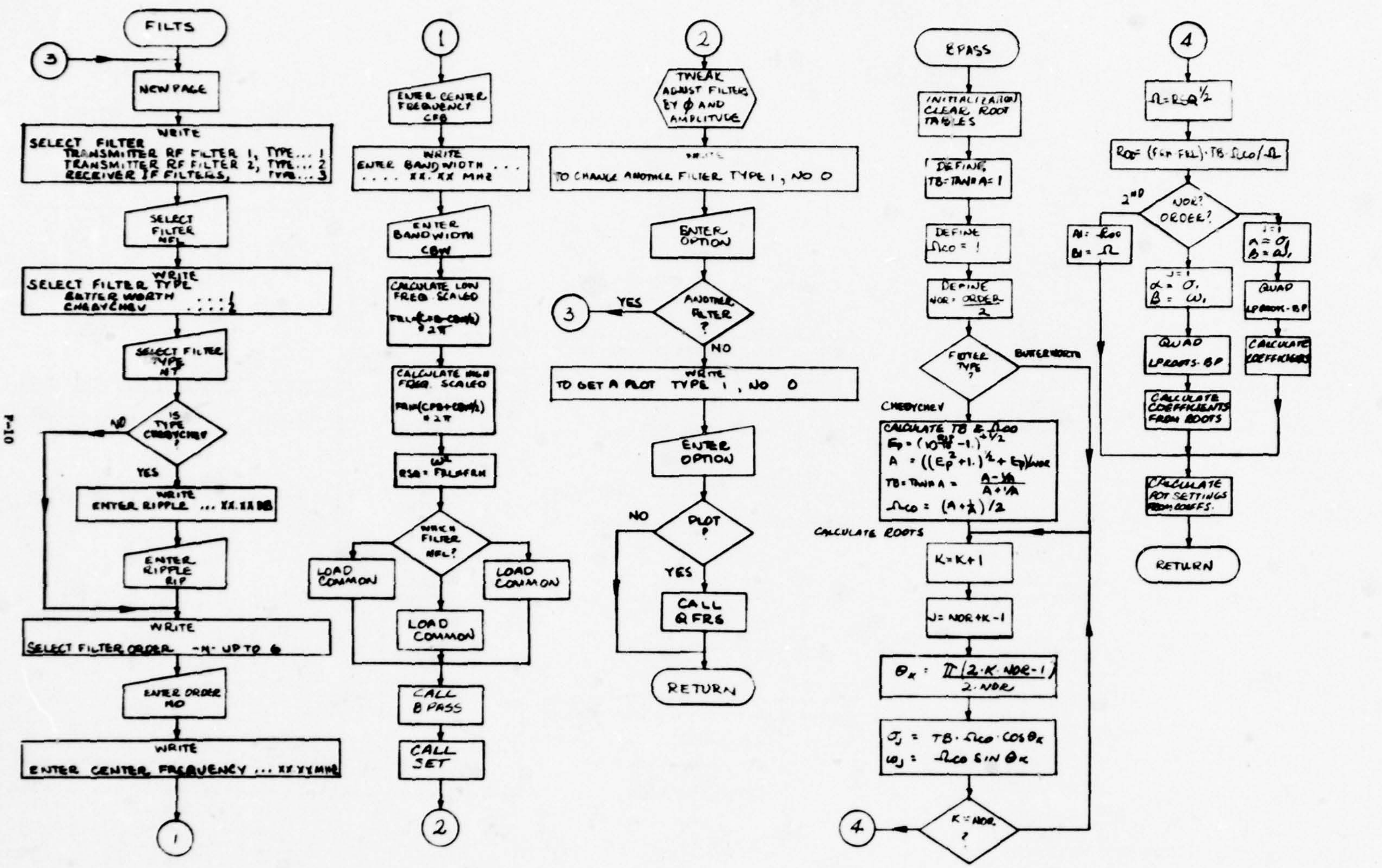

PSD
NEW PAGE
WRITE THE FOLLOWING STATEMENTS
TO GET THE SPECTRAL OCCUPANCY OF THE SIGNAL MEASURED AT
THE MODULATOR OUTPUT ...... TYPE 1
1ST TRANSMITTER FILTER ...... TYPE 2
... TYPE 3
2ND TRANSMITTER FILTER ...... TYPE 4
READ OPTION
SWITCH PSD CIRCUIT TO PEAK DETECTOR
SWITCH SELECTED INPUT TO PSD CIRCUIT
WRITE
ENTER NUMBER OF LAGS ...UP TO 2000.
READ LAGS RPTS NPTS=RPTS
WRITE
INPUT LOW FREQUENCY ....XX.X MHZ
READ LOW FREQ FQL
WRITE
INPUT HIGH FREQUENCY ...XX.X MHZ
READ HIGH FREQ FQH
CALCULATE SCALE FACTOR SC=2π10⁶/70
INITIALIZE OSC FREQ = FQL·SC AFREQ=(FQH-FQL)·SC AMP = .25
CALL OSC FREQ. GENERATOR
CALL PEAK READ PEAK DET OUTPUT OF PSD
ABSOLUTE VALUE
STORE IN DATA ARRAY
FIND MAX VALUE RMX & FREQ AT MAX VALUE CCF
GET NEXT FREQ. VALUE
I=I+1 I=NPTS?
YES
NO
SET CONTROL LINE
DISCONNECT PSD TO PEAK DET & SOURCE TO PSD
NORMALIZE DATA ANORM = DATA(I)/RMX
DETERMINE RATIO
RP= 10 Log ANORM
RP≤-.27
RP = -.27
STORE RP IN DATA ARRAY DATA(I) = RP
DETERMINE TOTAL POWER OVER FREQ. RANGE DEFINED
TP= TP+RP+27.
CALC .005 OF TOTAL POWER TB= .005·TP
CALC .5 OF TOTAL POWER TC = .5·TP
CALC .995 OF TP TH = .995·TP
INITIALIZE FREQ ACCUMULATOR DFQ = FQL DDF = DELO/SC
INITIAL ANOTHER TOTAL POWER = 0 TPA = 0
TPA = TPA + DATA(I) +27
TPA ≤ TPB
FRL= DFQ
TPA ≤ TPC
FRC = DFQ
TPA ≤ TPH
FRH = DFQ
UPDATE FREQ DFQ= DFQ + DDF
I=I+1 I=NPTS?
SCALE FREQ AT MAX VALUE CCF=CCF/SC
99% P.B WIDTH BW= FRH - FRL
OUTPUT .99 POWER BANDWIDTH IS 'BW' MHZ BW
OUTPUT CENTER OF POWER FRC
OUTPUT FREQ AT MAX POWER CCF
C/R TO CONTINUE
PLOT PSD SDPLT
WRITE
FOR ANOTHER PSD TYPE 1, NO 0
READ RESPONSE
IS IT 1?
RETURN

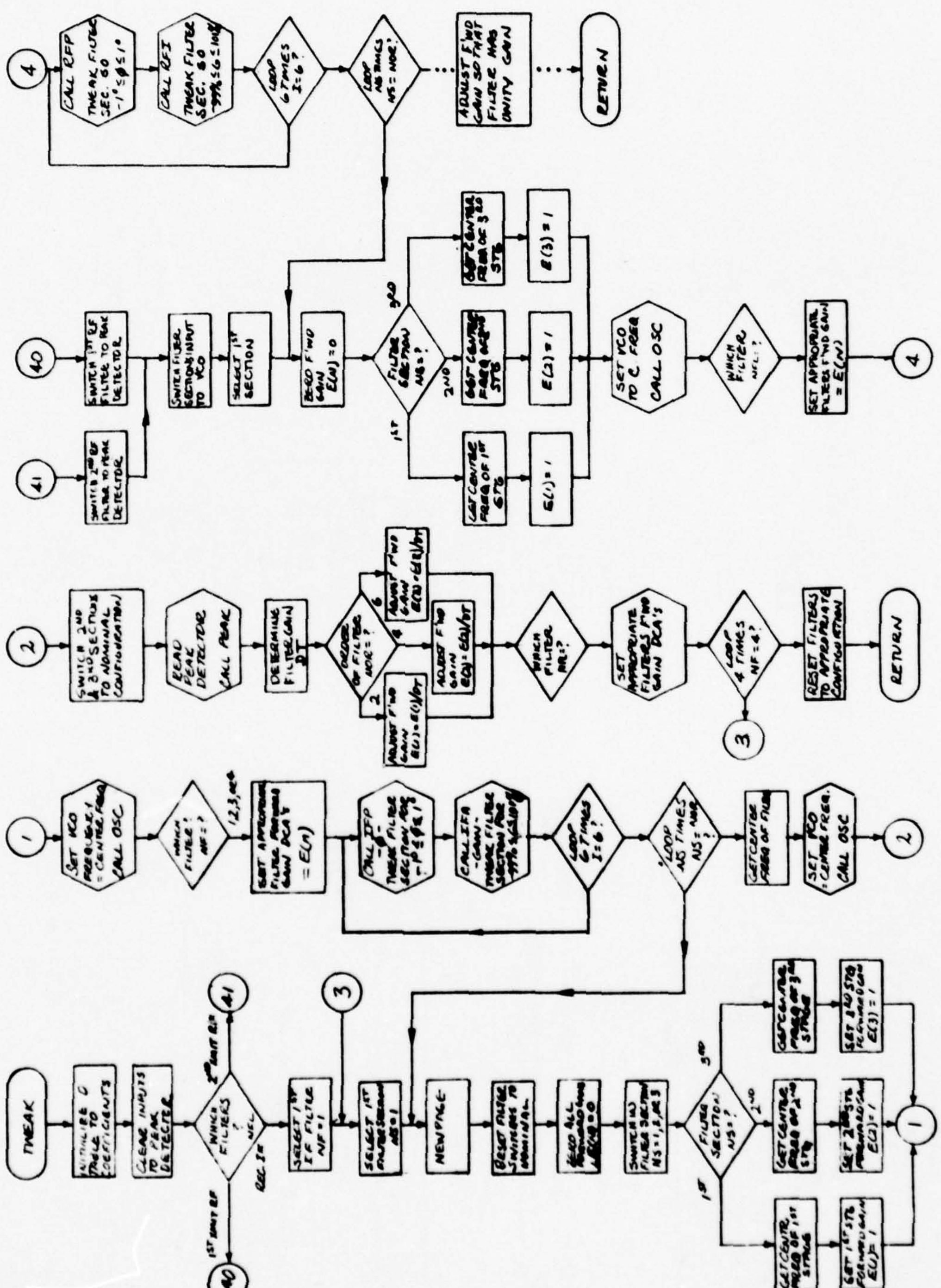


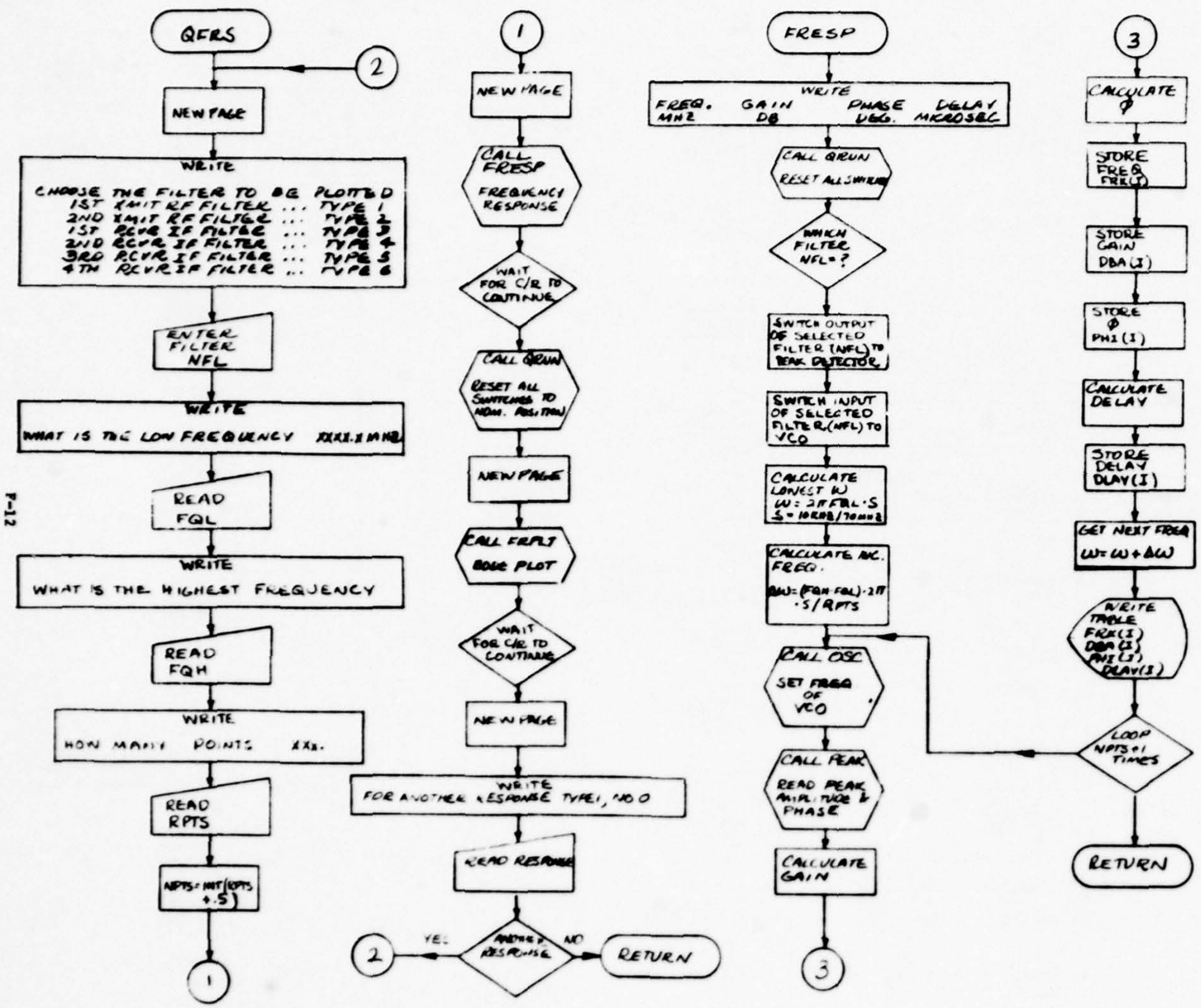
SDPLT
DEFINE THE WINDOW
DRAW 10 HORIZONTAL LINES FROM 0. TO -27 IN 3dB STEPS
DRAW 11 VERTICLE LINES EQUALLY SPACED
LABLE VERT. LINES FBL TO FBH IN (FBH-FBL)/10 STEPS
WRITE POWER - DB VS FREQUENCY - MHZ AS CAPTION
LABLE HORIZ LINES 0. TO -27 IN -3dB STEPS
PLOT PSD DATA
ENTER C/R TO CONTINUE
NEW PAGE
RETURN


BERT
NEWPG
0
WRITE
ENTER CHANNEL CONFIGURATION
1. RAYLEIGH
2. TROPOSCATTER
3. OUT
INPUT CHANNEL OPTION
GOTO OPTION
RAYLEIGH
CHANNEL OUT
TROPO-SCATTER
ENTER FRAME RATE ... UP 1 HR
CALL RAY RAYLEIGH
CALL CHAN TROPOSCATTER
CALL CHPLT PLOT PROFILE
TURN OFF AGC SETCLO ON 2
REMOVE CHANNEL SET CLS ON 3
SET S/N RATIO CALL STSNR
WRITE
ENTER RUN TIME XXX.X SEC.
INPUT RUN TIME RTM
INITIALIZE NBTS = 0 (NO OF BITS) NBER = 0 (NO OF ERRORS) NTST = 1 (BIT ERROR TEST) NBTL = 2000 RUN TIME IN BITS
1
START & RUN BER FOR 2 SEC. TO AVOID TRANSIENT CALL TROPO
REINITIALIZE NBTS = 0 NBER = 0 NTST = 1 NBTL = RTM x 10^4 NERT =
CALL BEGIN REENTER TROPO
CALCULATE BIT ERROR RATE
OUTPUT TOTAL BITS BIT ERRORS BIT ERROR RATE
TURN OFF AGC SETCLO ON 2
SET S/N RATIO TO 100.
TAKE CHANNEL OUT SET CLS ON 3
WRITE
FOR ANOTHER BIT ERROR TEST TYPE 1, NO 0
INPUT RESPONSE
ANOTHER BER TEST ?
YES
NO
RETURN
TROPO
CLEAR INTERFACE
SELECT CONSOLE 3 & LOAD INTERRUPT MASK
LOAD PRI 0 PIVOT 'X BFR
LODE PRI 1 PIVOT 'X BIT
LOAD PRI 2 PIVOT 'X BER
LOAD TROPO PROFILE APPR. IN SCAD ARRAY 96 VALUES
TURN ON INTERRUPTS
BEGIN
REINIT 96 COUNT
REINIT FILTER PARAMETERS
REINIT DCA SELECTED
LOOP
READ RANDOM DATA INPUT CALL RED
OUTPUT PRESENT FILTER OUTPUT JAMEM
FILTER
I = I+1 I = 96
IS NFRTS ≥ BFR FRAME RATE DELAY
2
CNTB
COUNT ERRORS NBER = NBER + BER BER = 0
COUNT BITS NBTS = NBTS + BIT BIT = 0
IS ? NBTS ≥ NBTL RUN TIME UP ?
TURN OFF INTERRUPTS
RETURN


CHAN
WRITE
FOR A DELAY PROFILE TYPE 1, NO 0
READ OPTION NN
DELAY PROFILE ?
NO
YES
NEW PAGE
WRITE
ENTER PATH LENGHT IN MILES
ENTER PATHLENGHT DI
WRITE
IF THIS IS A SMOOTH EARTH PATH TYPE 1, NO 0
TYPE RESPONSE
SMOOTH EARTH ?
YES
NO
WRITE
ENTER HORIZONTAL ANGLES IN DEGREES
WRITE
ALPHA = XX.X
ENTER ALPHA
WRITE
BETA = XX.X
ENTER BETA
SCALE ALPHA & BETA BY .00872
WRITE
ENTER EFFECTIVE EARTH (K).
ENTER EFFECTIVE EARTH AKI
WRITE
ENTER ANTENNA BEAMWIDTHS IN DEGREES
WRITE
BEAMWIDTH A = XX.X
ENTER BEAMWIDTH A BIA
WRITE
BEAMWIDTH B = XX.X
ENTER BEAMWIDTH B BIB
SCALE BIA & BIB BY .00872
WRITE
ENTER NUMBER OF POINTS DESIRED AT .20 μS SPACING
ENTER NUMBER NI
CALCULATE PROFILE
WRITE
DELAY USEC POWER AMPLITUDE
OUTPUT TABLE OF DELAYS, POWER AND AMPLITUDE
WRITE
DO YOU WANT ANOTHER PATH. 1=YES, 0=NO
DO YOU ?
YES
CONNECT AGC RESET CL 0 CNSL 2
CONNECT CHANNEL RESET CL 5 CNSL 3
RETURN
RAY
CONNECT CHANNEL RESET CL 5 CNSL 3
CONNECT AGC RESET CL 0 CNSL 2
SET 1ST PROFILE TERM = 1.0
ZERO ALL OTHERS
RETURN
CHNL
CALL CHAN
CALL CHPLT
CALL TROPO
RETURN


FILTS
NEW PAGE
WRITE
SELECT FILTER
TRANSMITTER RF FILTER 1, TYPE... 1
TRANSMITTER RF FILTER 2, TYPE... 2
RECEIVER IF FILTERS, TYPE... 3
SELECT FILTER NFL
WRITE
SELECT FILTER TYPE
BUTTERWORTH ... 1
CHEBYCHEV ... 2
SELECT FILTER TYPE NT
IS TYPE CHEBYCHEV ?
NO
YES
WRITE
ENTER RIPPLE ... XX.XX DB
ENTER RIPPLE RIP
WRITE
SELECT FILTER ORDER -N- UP TO 6
ENTER ORDER NO
WRITE
ENTER CENTER FREQUENCY ... XX.XX MHZ
ENTER CENTER FREQUENCY CFQ
WRITE
ENTER BANDWIDTH ...
.... XX.XX MHZ
ENTER BANDWIDTH CBW
CALCULATE LOW FREQ SCALED
CALCULATE HIGH FREQ. SCALED
WHICH FILTER NFL?
LOAD COMMON
LOAD COMMON
LOAD COMMON
CALL B PASS
CALL SET
TWEAK
ADJUST FILTERS BY ϕ AND AMPLITUDE
WRITE
TO CHANGE ANOTHER FILTER TYPE 1, NO 0
ENTER OPTION
ANOTHER FILTER ?
YES
NO
WRITE
TO GET A PLOT TYPE 1, NO 0
ENTER OPTION
PLOT ?
NO
YES
CALL QFRS
RETURN
BPASS
INITIALIZATION CLEAR ROOT TABLES
DEFINE TB=TANθA=1
DEFINE Ωco = 1
DEFINE NOR = ORDER/2
FILTER TYPE ?
BUTTERWORTH
CHEBYCHEV
CALCULATE TB & Ωco
CALCULATE ROOTS
K=K+1
J= NOR+K-1
CALCULATE POT SETTINGS FROM COEFFS.
K = NOR ?
NOR? ORDER?
2ND
QUAD LPROOTS-BP
CALCULATE COEFFICIENTS FROM ROOTS
CALCULATE COEFFICIENTS
RETURN
1
2
3
4


TWEAK
CALL OSC
CALL PEAK
CALL RFP
CALL RFI
NEWPAGE
RETURN
RETURN


QFRS
2
NEW PAGE
WRITE
CHOOSE THE FILTER TO BE PLOTTED
1ST XMIT RF FILTER ... TYPE 1
2ND XMIT RF FILTER ... TYPE 2
1ST RCVR IF FILTER ... TYPE 3
2ND RCVR IF FILTER ... TYPE 4
3RD RCVR IF FILTER ... TYPE 5
4TH RCVR IF FILTER ... TYPE 6
ENTER FILTER NFL
WRITE
WHAT IS THE LOW FREQUENCY XXXX.X MHZ
READ FQL
WRITE
WHAT IS THE HIGHEST FREQUENCY
READ FQH
WRITE
HOW MANY POINTS XXX.
READ RPTS
NPTS=INT(RPTS+.5)
1
1
NEW PAGE
CALL FRESP
FREQUENCY RESPONSE
WAIT FOR C/R TO CONTINUE
CALL QRUN
RESET ALL SWITCHES TO NOM. POSITION
NEW PAGE
CALL FRPLT
BODE PLOT
WAIT FOR C/R TO CONTINUE
NEW PAGE
WRITE
FOR ANOTHER RESPONSE TYPE 1, NO 0
READ RESPONSE
ANOTHER RESPONSE
YES
NO
2
RETURN
FRESP
WRITE
FREQ. MHZ
GAIN DB
PHASE DEG.
DELAY MICROSEC
CALL QRUN
RESET ALL SWITCHES
WHICH FILTER NFL=?
SWITCH OUTPUT OF SELECTED FILTER (NFL) TO PEAK DETECTOR
SWITCH INPUT OF SELECTED FILTER (NFL) TO VCO
CALCULATE LOWEST W
W=2πFQL·S
S=10RAD/70MHZ
CALCULATE INC. FREQ.
ΔW=(FQH-FQL)·2π·S/RPTS
CALL OSC
SET FREQ OF VCO
CALL PEAK
READ PEAK AMPLITUDE & PHASE
CALCULATE GAIN
3
3
CALCULATE φ
STORE FREQ FRE(I)
STORE GAIN DBA(I)
STORE φ PHI(I)
CALCULATE DELAY
STORE DELAY DLAY(I)
GET NEXT FREQ
W=W+ΔW
WRITE TABLE
FRE(I)
DBA(I)
PHI(I)
DLAY(I)
LOOP NPTS+1 TIMES
RETURN

APPENDIX G

DAR SIMULATION OUTPUTS

1 POWER SPECTRAL DENSITY

2 FREQUENCY RESPONSE

3 EYE PATTERN

4. SINGLE BIT ERROR TEST

7 PLOT DELAY PROFILE

8. ALTER FILTER PARAMETERS

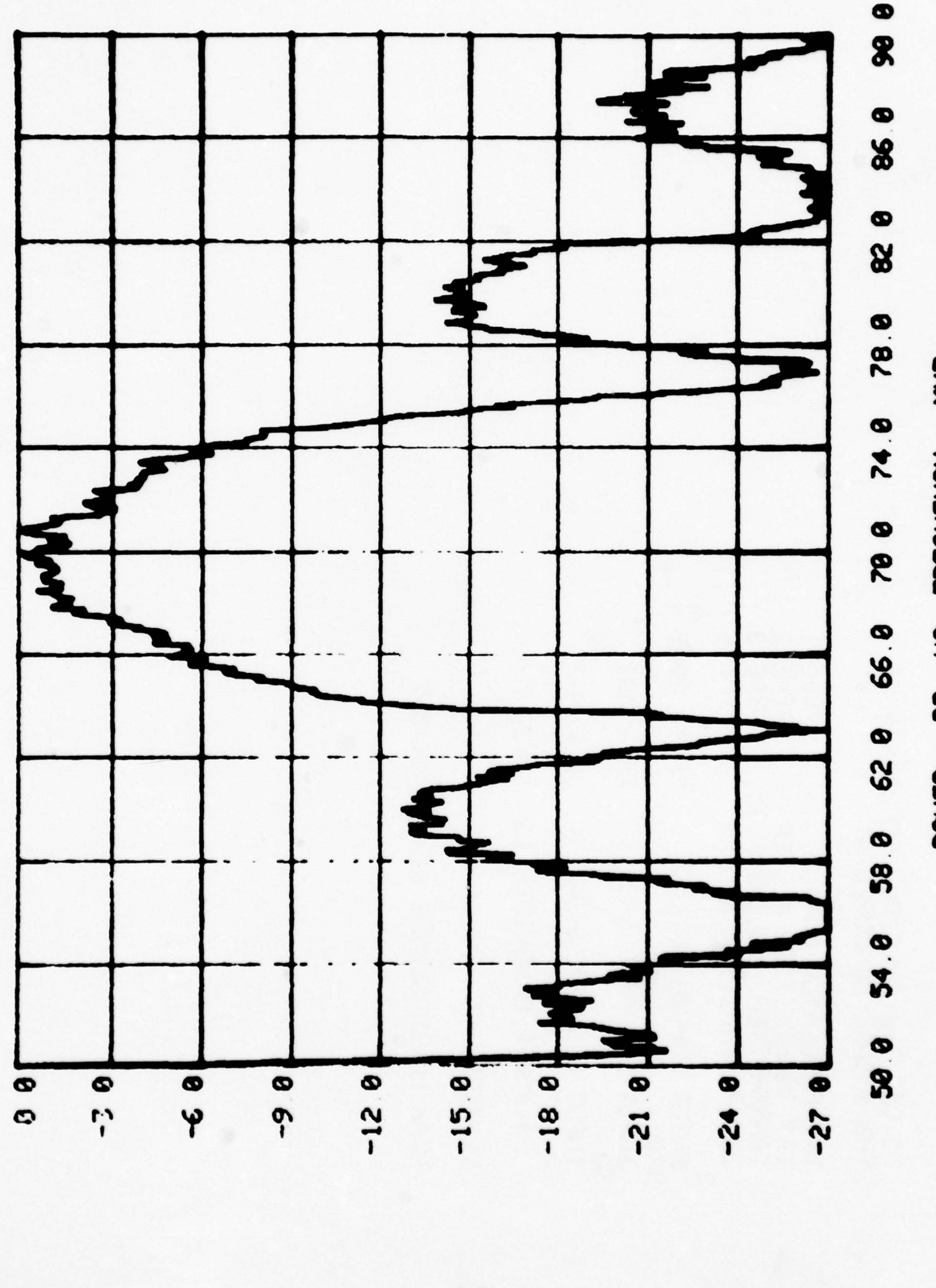
9 RETURN TO NOMINAL SYSTEM

10. ALTER SYSTEM OR PARAMETERS

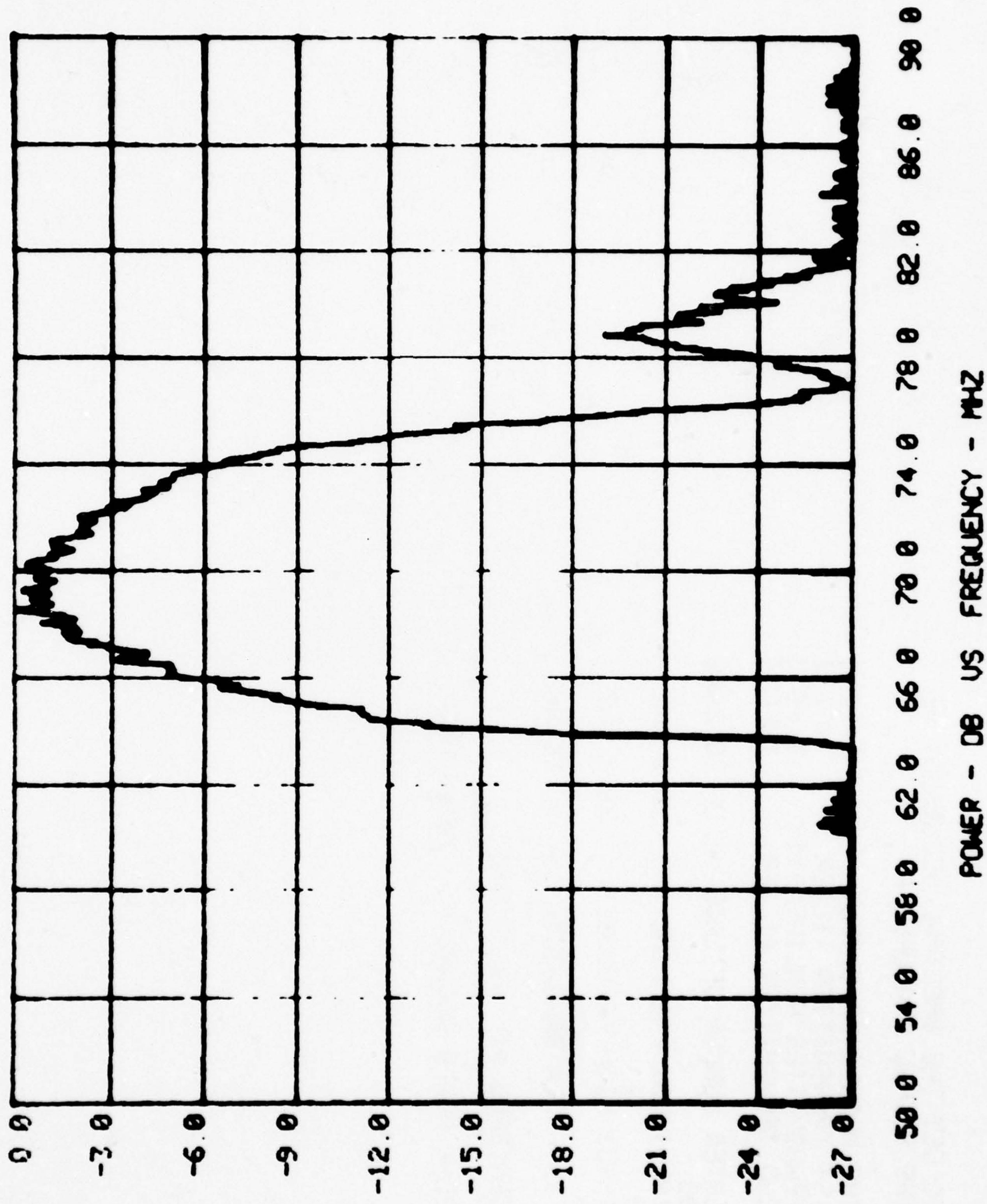
SELECT THE NUMBER OF AN OPTION ABOVE

```
IHP SYSTEM CONFIGURATION

1  RUN NUMBER =        1.0000

2  TIMEGATE =   50 0 PERCENT

3  TRANSMITTER FILTERS

     BEFORE NONLINEARITY   ... IN
     BANDWIDTH      =  14.00 MHZ
     CENTER FREQ.   =  70.00 MHZ
     NO OF POLES    = 6
     1. BUTTERWORTH

     AFTER NONLINEARITY   ....IN
     BANDWIDTH      =  14.00 MHZ
     CENTER FREQ    =  70.00 MHZ
     NO OF POLES    = 6
     1. BUTTERWORTH

4. NONLINEAR DEVICE
     OUT

5. CHANNEL CONFIGURATION
     3. OUT

6. AGC
     OUT

7. RECEIVER IF FILTERS
     BANDWIDTH      =  14.00 MHZ
     CENTER FREQ.   =  70 00 MHZ
     NO OF POLES    = 6
     1. BUTTERWORTH

8. COHERENT FILTER GAIN =     0.7500

9  S/N RATIO = 100.00 DB

10  DIVERSITY
      3. QUAD

12  DRIVE POWER = -20.00 DB

13. RUN TIME =    3600.00 SEC

14. SCRAMBLER
      OUT
```

```
TO GET THE SPECTRAL OCCUPANCY OF
THE SIGNAL MEASURED AT

THE MODULATOR OUTPUT  . .      TYPE 1
1ST TRANSMITTER FILTER  . .    TYPE 2
TRANSMITTER NONLINEARITY       TYPE 3
2ND TRANSMITTER FILTER  . .    TYPE 4
1
 ENTER NUMBER OF LAGS . . UP TO 2000.
500
 INPUT LOW FREQUENCY . . . .XX.X MHZ
50
 INPUT HIGH FREQUENCY . . .XX.X MHZ
90.
  99 POWER BANDWIDTH IS  38.56 MHZ

 CENTERED AT  69.20 MHZ

 PEAK POWER OCCURS AT  70.96 MHZ
```

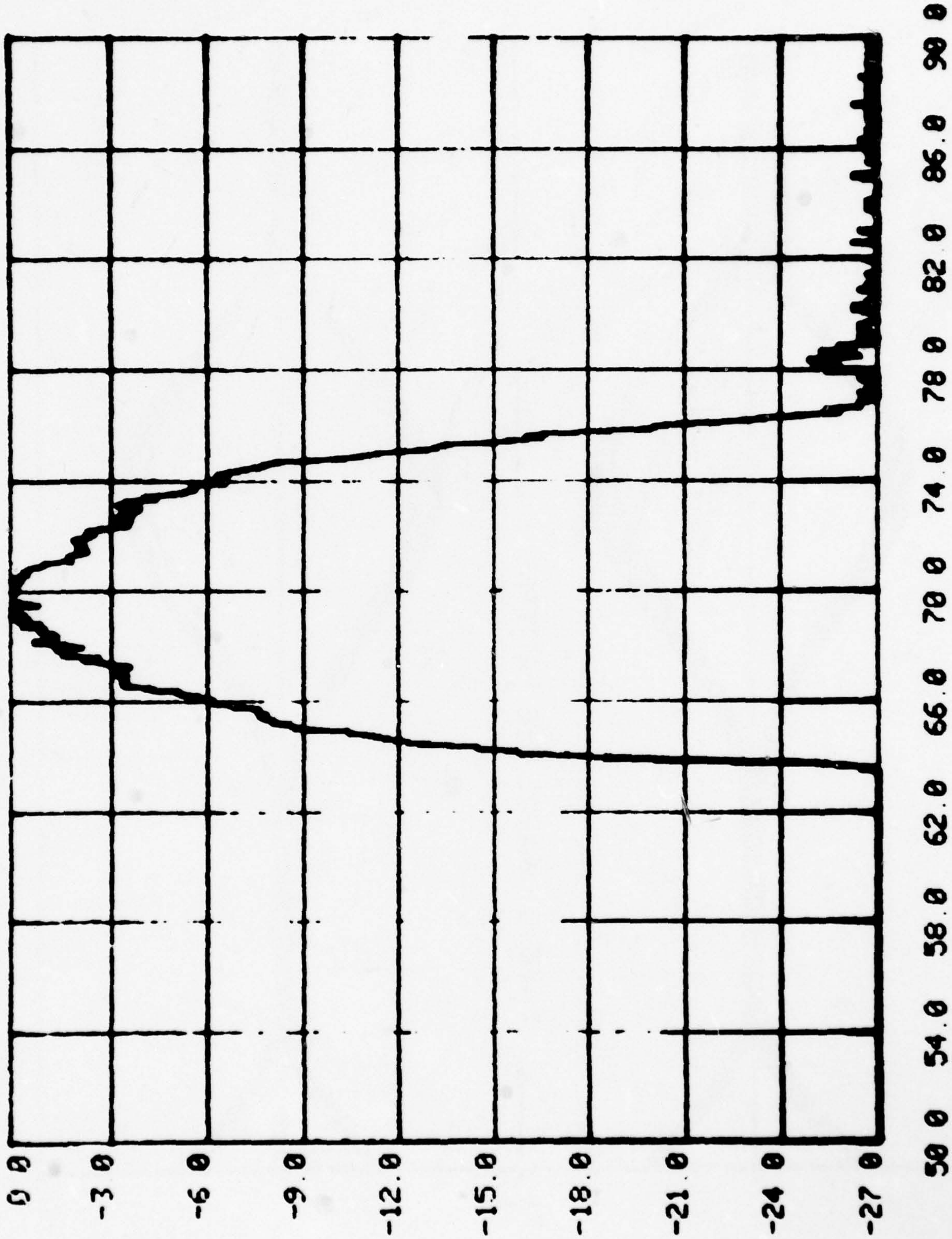

0.0
-3.0
-6.0
-9.0
-12.0
-15.0
-18.0
-21.0
-24.0
-27.0
50.0
54.0
58.0
62.0
66.0
70.0
74.0
78.0
82.0
86.0
90.0
POWER - DB VS FREQUENCY - MHZ

```
TO GET THE SPECTRAL OCCUPANCY OF
THE SIGNAL MEASURED AT

THE MODULATOR OUTPUT  . . .      TYPE 1
1ST TRANSMITTER FILTER           TYPE 2
TRANSMITTER NONLINEARITY  . .    TYPE 3
2ND TRANSMITTER FILTER  . . .    TYPE 4
2
ENTER NUMBER OF LAGS . . UP TO 2000
500
INPUT LOW FREQUENCY . . . XX.X MHZ
50
INPUT HIGH FREQUENCY . . .XX.X MHZ
90
.99 POWER BANDWIDTH IS  18.32 MHZ

CENTERED AT  70.16 MHZ

PEAK POWER OCCURS AT  68.64 MHZ
```

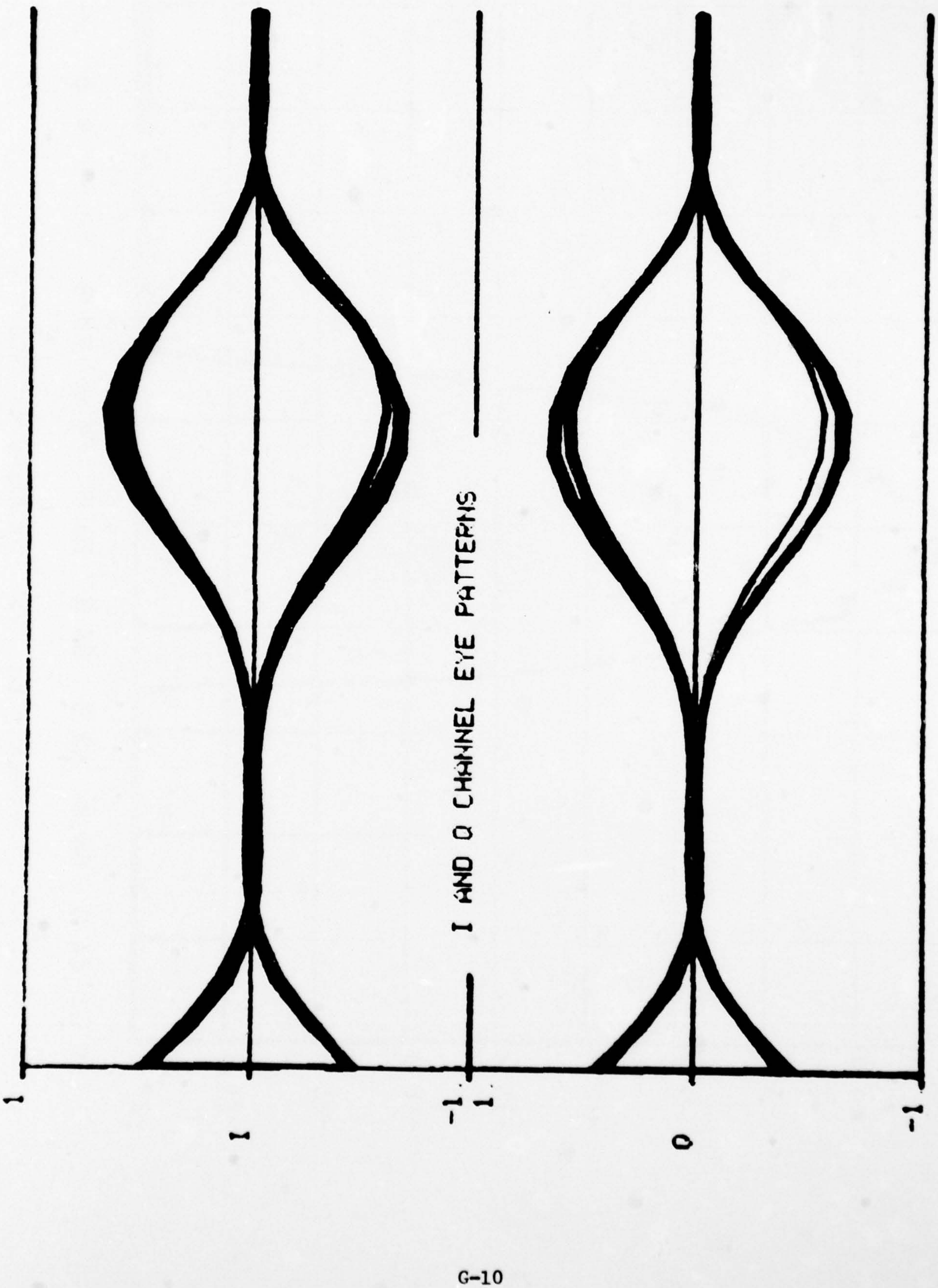


0.0
-3.0
-6.0
-9.0
-12.0
-15.0
-18.0
-21.0
-24.0
-27.0
50.0
54.0
58.0
62.0
66.0
70.0
74.0
78.0
82.0
86.0
90.0
POWER - DB VS FREQUENCY - MHZ

```
TO GET THE SPECTRAL OCCUPANCY OF
THE SIGNAL MEASURED AT

THE MODULATOR OUTPUT           TYPE 1
1ST TRANSMITTER FILTER         TYPE 2
TRANSMITTER NONLINEARITY       TYPE 3
2ND TRANSMITTER FILTER         TYPE 4
4
ENTER NUMBER OF LAGS ... UP TO 2000
500
INPUT LOW FREQUENCY ... XX.X MHZ
50
INPUT HIGH FREQUENCY    XX.X MHZ
90
.99 POWER BANDWIDTH IS  16.16 MHZ

CENTERED AT  69.92 MHZ

PEAK POWER OCCURS AT  70.64 MHZ
```



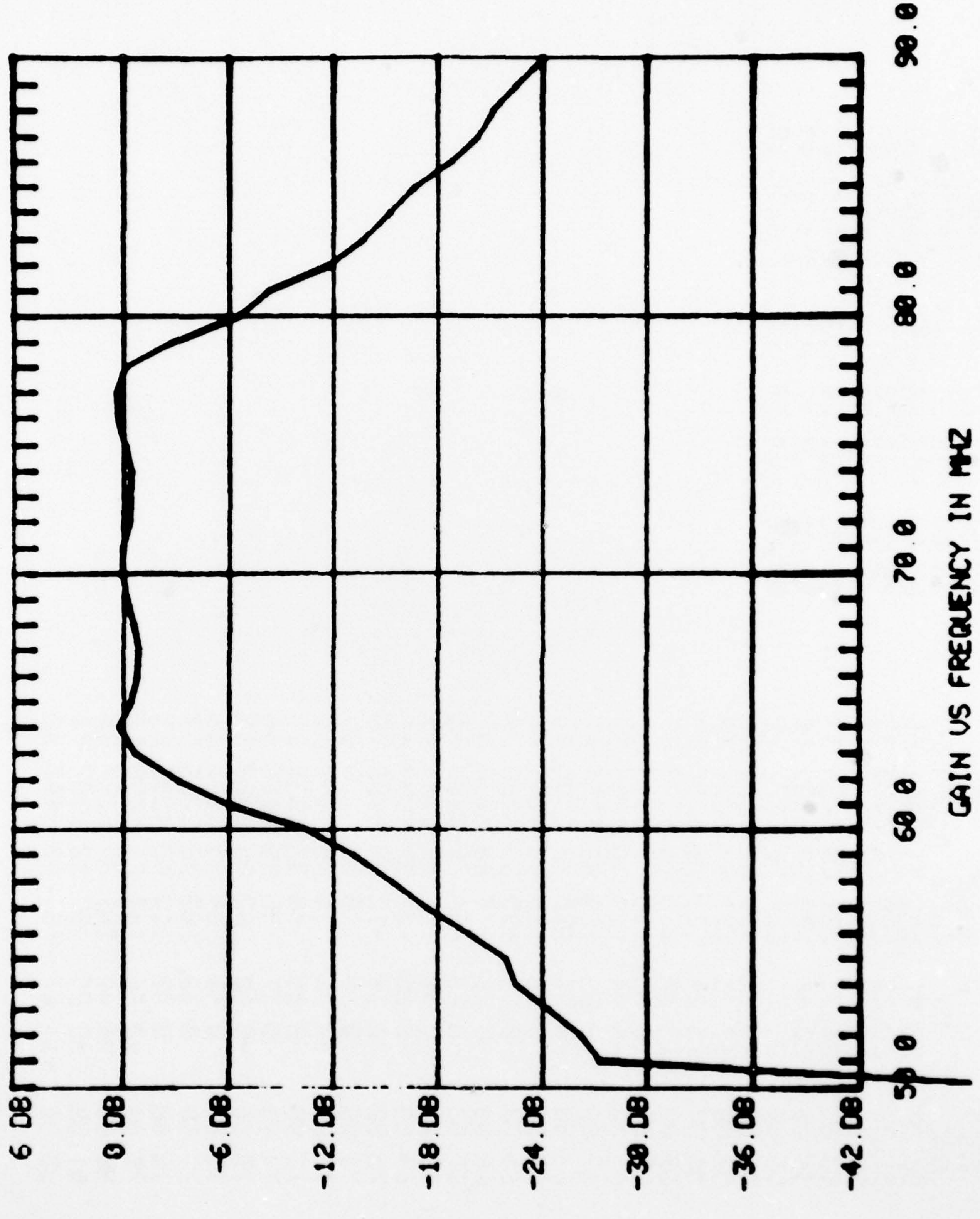
POWER - DB VS FREQUENCY - MHZ


I AND Q CHANNEL EYE PATTERNS
1
I
-1
1
Q
-1

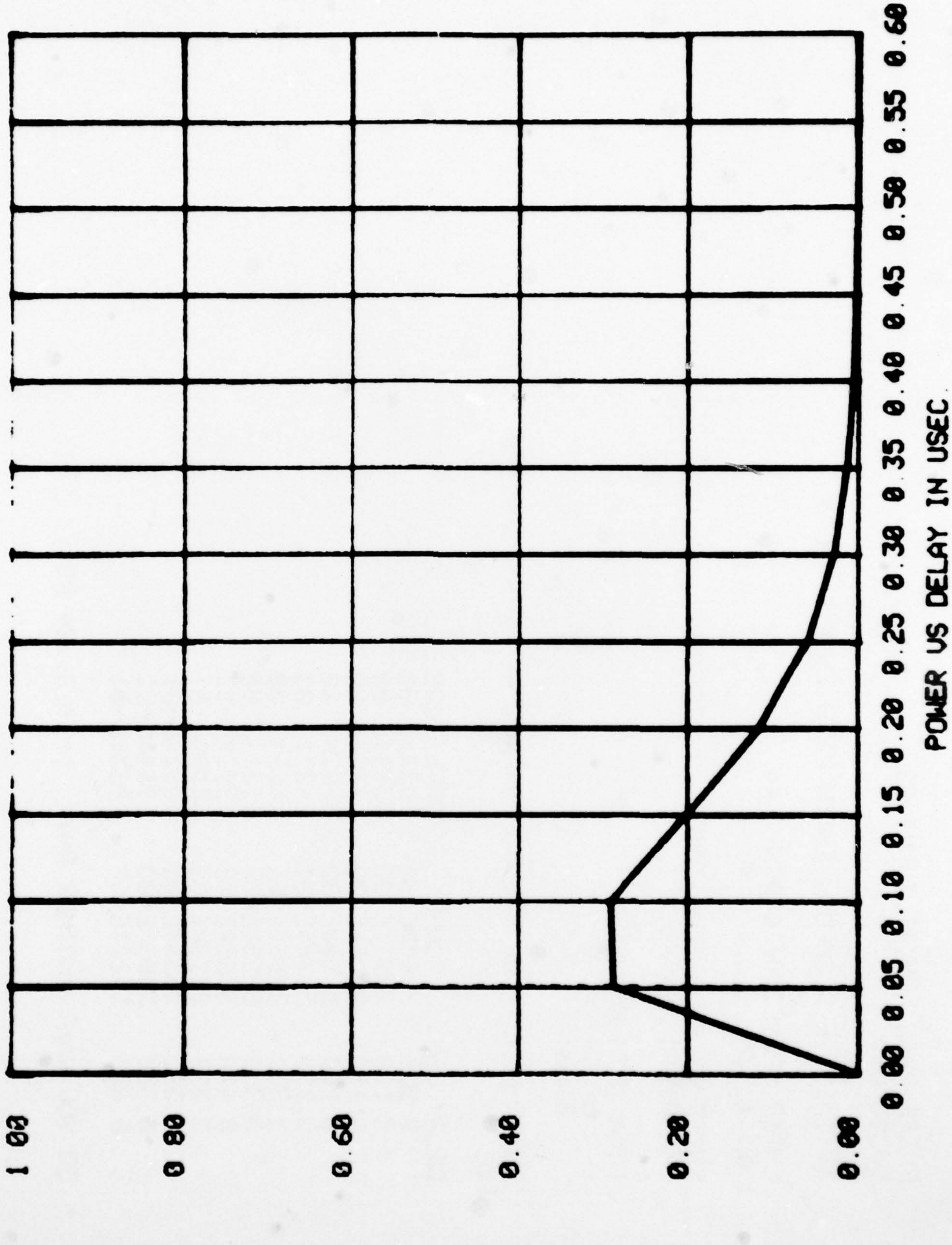
```
FILTER ALTERATION AND VERIFICATION

SELECT FILTER
     TRANSMITTER RF FILTER 1,    TYPE    1
     TRANSMITTER RF FILTER 2,    TYPE    2
     RECEIVER IF FILTERS,        TYPE    3
1

SELECT FILTER TYPE
     BUTTERWORTH   . 1
     CHEBYCHEV .   . 2
2
     ENTER RIPPLE ... XX.XX DB
 1

SELECT FILTER ORDER  -N- UP TO 6
6

ENTER CENTER FREQUENCY  . . XX.XX MHZ
70.
ENTER BANDWIDTH ......... XX.XX MHZ
14.
```

```
CHOOSE THE FILTER TO BE PLOTTED
    1ST XMIT RF FILTER     TYPE 1
    2ND XMIT RF FILTER     TYPE 2
    1ST RCVR IF FILTER     TYPE 3
    2ND RCVR IF FILTER     TYPE 4
    3RD RCVR IF FILTER     TYPE 5
    4TH RCVR IF FILTER     TYPE 6
WHAT IS THE LOW FREQUENCY  XXXX.X MHZ
50.
 WHAT IS THE HIGHEST FREQUENCY
90.
 HOW MANY POINTS XXX
40.
```

FREQ. MHZ	GAIN DB	PHASE DEG	DELAY MICROSEC
50.00	-52.81	152.31	8461.51
51.00	-27.29	144.74	7883.39
52.00	-26.09	122.18	6526.72
53.00	-24.31	122.60	6425.33
54.00	-22.44	123.08	6331.46
55.00	-21.86	124.30	6277.99
56.00	-19.74	125.57	6228.86
57.00	-17.25	127.87	6231.42
58.00	-15.24	131.16	6281.83
59.00	-13.00	135.46	6377.66
60.00	-10.30	140.73	6515.51
61.00	-5.84	149.45	6805.59
62.00	-2.89	168.62	7554.47
63.00	-0.57	188.37	8305.41
64.00	0.36	-109.08	-4734.47
65.00	-0.32	-95.63	-4086.76
66.00	-0.70	-77.22	-3250.07
67.00	-0.73	-64.72	-2683.32
68.00	-0.48	-49.98	-2041.49
69.00	-0.06	-27.32	-1099.81
70.00	0.14	-12.40	-492.16
71.00	0.16	0.00	0.00
72.00	-0.26	16.78	647.56
73.00	-0.25	40.32	1534.24
74.00	-0.37	50.26	1806.50
75.00	-0.02	62.88	2328.83
76.00	0.40	84.85	3101.28
77.00	0.52	103.58	3736.53
78.00	0.02	119.40	4252.03
79.00	-2.66	144.76	5090.12
80.00	-6.40	181.09	6287.89
81.00	-8.25	87.12	2987.71
82.00	-11.67	-161.40	-5467.52
83.00	-13.62	-147.75	-4944.90
84.00	-15.23	-143.82	-4756.05
85.00	-16.66	-141.77	-4633.08
86.00	-18.72	-139.53	-4506.65
87.00	-20.30	-137.77	-4398.73
88.00	-21.20	-137.52	-4341.03
89.00	-22.47	-137.50	-4291.49
90.00	-24.10	-137.77	-4252.10

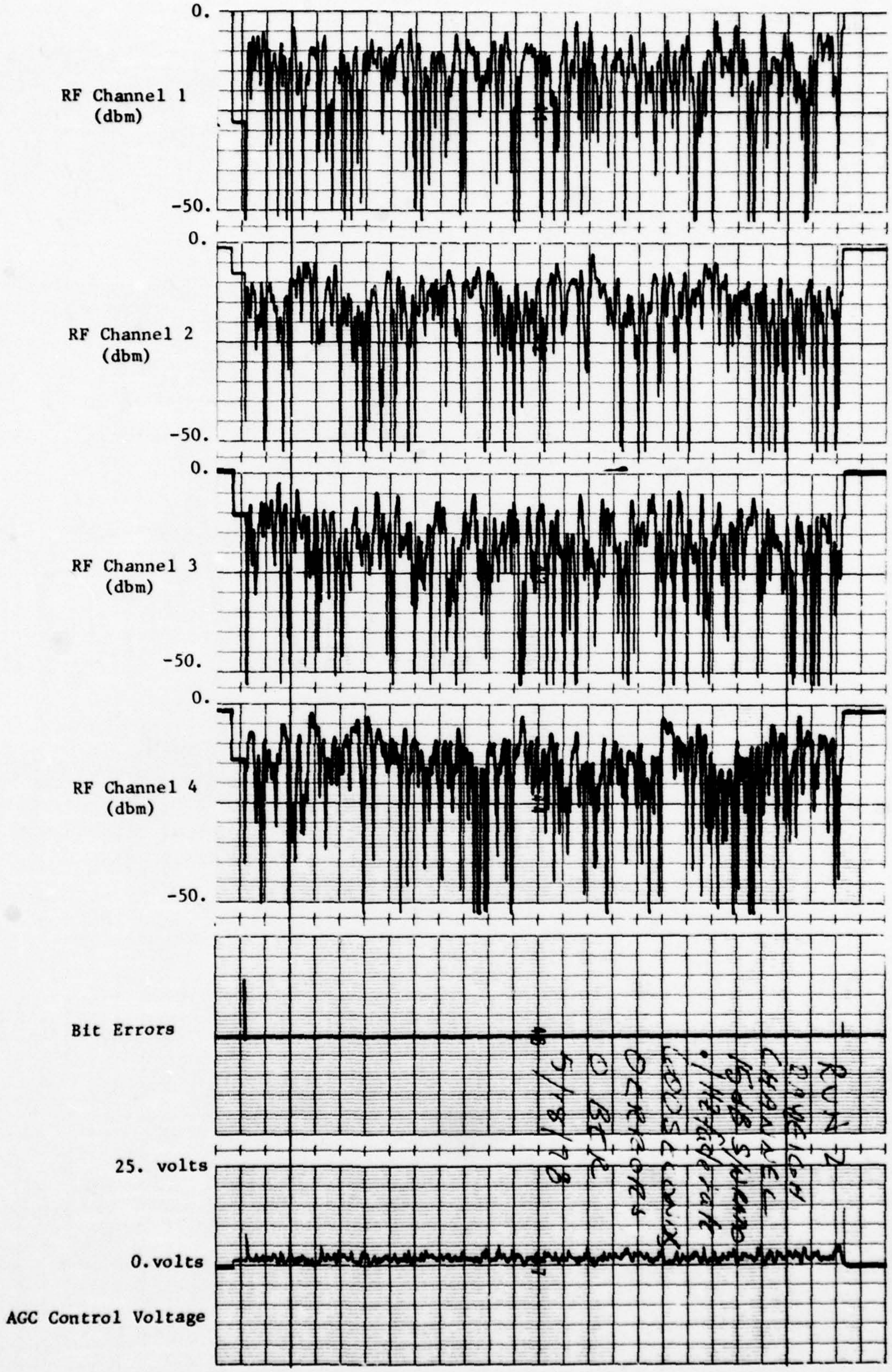

6 DB
0 DB
-6 DB
-12 DB
-18 DB
-24 DB
-30 DB
-36 DB
-42 DB
50 0
60 0
70 0
80 0
90 0
GAIN VS FREQUENCY IN MHZ

```
ENTER PATH LENGHT IN MILES
.50250 000

IF THIS IS A SMOOTH EARTH PATH TYPE 1, NO 0

ENTER EFFECTIVE EARTH  (K)
1 33 1.330

ENTER ANTENNA BEAMWIDTHS IN DEGREES
BEAMWIDTH A = XX.X
6
BEAMWIDTH B = XX.X
6    0.600
     0.600

ENTER NUMBER OF POINTS DESIRED AT 50 NS SPACING
12.

DELAY USEC    POWER         AMPLITUDE
   0.050    .2866*E 00    .5353*E 00
   0.100    .2893*E 00    .5379*E 00
   0.150    .2005*E 00    .4478*E 00
   0.200    .1150*E 00    .3392*E 00
   0.250    .5874*E-01    .2423*E 00
   0.300    .2786*E-01    .1669*E 00
   0.350    .1255*E-01    .1120*E 00
   0.400    .5466*E-02    .7393*E-01
   0.450    .2313*E-02    .4810*E-01
   0.500    .9550*E-03    .3091*E-01
   0.550    .3860*E-03    .1964*E-01
   0.600    .1527*E-03    .1235*E-01

DO YOU WANT ANOTHER PATH. 1= YES, 0= NO.
```

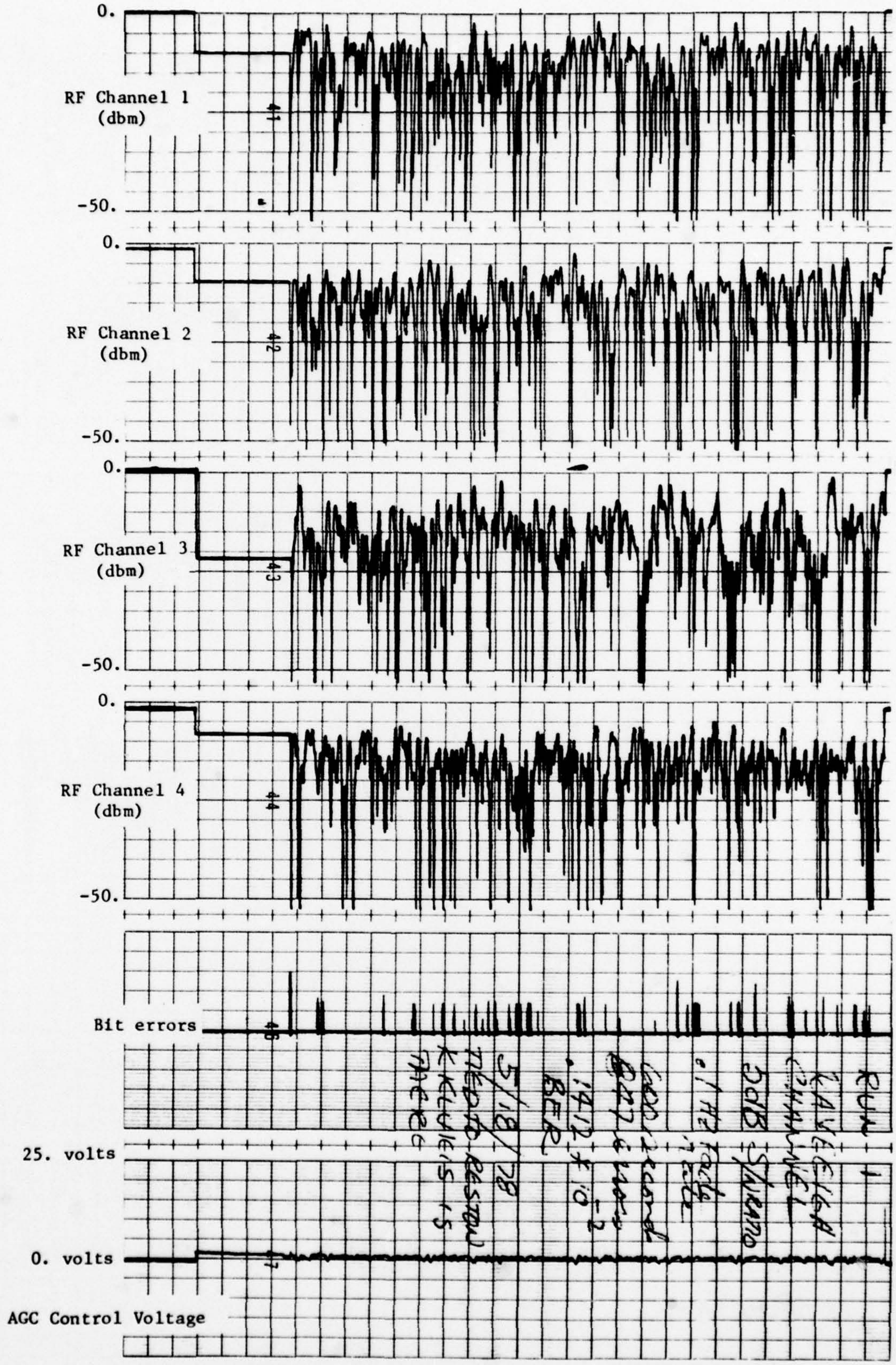

1.00
0.80
0.60
0.40
0.20
0.00
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
POWER VS DELAY IN USEC

```
ENTER CHANNEL CONFIGURATION
      1. RAYLEIGH
      2. TROPOSCATTER
      3. OUT
1
 ENTER FADE RATE      1 HZ MAXIMUM
 1
 TO INPUT NOISE . . . .TYPE 1, NO 0
1
 WHAT S/N RATIO WOULD YOU LIKE
5
 ENTER RUN TIME XXX.X SEC.
600.
 TOTAL BITS = . . . . . ,      600000
 BIT ERRORS = . . . . . ,         847
 BIT ERROR RATE =   .0.1412E-02

 FOR ANOTHER BIT ERROR TEST TYPE 1, NO 0
```

```
ENTER CHANNEL CONFIGURATION
      1. RAYLEIGH
      2  TROPOSCATTER
      3  OUT

ENTER FADE RATE .    1 HZ MAXIMUM
1
TO INPUT NOISE ...   TYPE 1, NO 0
1
WHAT S/N RATIO WOULD YOU LIKE
15
ENTER RUN TIME XXX.X SEC.
600.
TOTAL BITS = ......,       600248
BIT ERRORS = ....,              0
BIT ERROR RATE =   ,0.0000E 01

FOR ANOTHER BIT ERROR TEST TYPE 1, NO 0
```



ANALOG RECORDING OF RAYLEIGH FADING CHANNEL ENVELOPES, BIT ERRORS, AND AGC CONTROL VOLTAGE



ANALOG RECORDING OF RAYLEIGH FADING CHANNEL ENVELOPES,
BIT ERRORS, AND AGC CONTROL VOLTAGE

APPENDIX H

ABBREVIATIONS AND ACRONYMS

ABC	- Analog Baseband Combiner
ABE	- Adaptive Backward Equalizer
ACAS	- Automatic Central Alarm System
ACOC	- Area Communications Operations Center
A/D	- Analog to Digital
ADC	- Analog to Digital Converter
ADFE	- Adaptive Decision Feedback Equalizer
AFE	- Adaptive Forward Equalizer
AGC	- Automatic Gain Control
AMN	- Amplitude Modulated Noise
ATB	- All-Trunks-Busy
ATEC	- Automatic Technical Control
AUTODIN	- Automatic Digital Network
AUTOSEVOCOM	- Automatic Secure Voice Communication
AUTOVON	- Automatic Voice Network
BER	- Bit Error Rate
BITE	- Built-In Test Equipment
BPSK	- Binary Phase Shift Keyed
CCD	- Charge Coupled Device
CON	- Controller Task
CPU	- Central Processing Unit
CRT	- Cathode Ray Tube
CSD	- Computational Sciences Department
CSS	- Command Substitution System
CW	- Continuous Wave
D/A	- Digital to Analog Switch
DAC	- Digital to Analog Converter
DAR	- Distortion Adaptive Receiver
DAU	- Digital Applique Unit
DAX	- Digital Access Exchange
DCA	- Defense Communications Agency
DCAOC	- Defense Communications Agency Operations Center
DCC	- Destination Code Cancellation
DCEC	- Defense Communication Engineering Center
DCS	- Defense Communications System
DDD	- Direct Distance Dialed
DEB	- Digital European Backbone

DM - Delta Modulation
DOCC - Defense Communications Agency Operations Control Complex
DRAMA - Digital Radio and Multiplexer
DSCS - Defense Satellite Communication System
DTMF - Dual Tone Multifrequency

FCO - Facility Control Office
FDM - Frequency Division Multiples
FKV - Frankfurt/Koenigstuhl/Vahingen
FM - Frequency Modulation
FSK - Frequency Shift Keyed

GOS - Grade Of Service

IF - Intermediate Frequency

LOS - Line Of Sight

MAS - Measurement Acquisition System
MFX - Multifrequency Transceiver
MOE - Measure Of Effectiveness
MUX - Multiplexer

NCS - Node Control Subsystem
NCE - Network Control Element

OCE - Operations Control Element
OOK - On-Off Keyed

PAM - Pulse Amplitude Modulation
PBX - Private Branch Exchange
PCM - Pulse Code Modulation
PCW - Pulsed Continuous Wave
PLL - Phase Lock Loop
PM - Phase Modulation
PMB - Pilot-Make-Busy
PPM - Pulse Position Modulation
PSD - Power Spectral Density
PSK - Phase Shift Keyed

QPR - Quadrature Partial Response
QPSK - Quadrature Phase Shift Keyed

RCOC - Regional Communications Operation Center
RF - Radio Frequency
RMS - Root Mean Squared
ROM - Read Only Memory
RSJ - Register Sender Junctor
RSL - Received Signal Level
RTAC - Real Time Adaptive Control

SIM	- Simulator Task
SOS	- Speed Of Service
SOW	- Statement Of Work
TCE	- Terminal Control Element
TCF	- Technical Control Facility
TCR	- Touch Call Receivers
TDCS	- Traffic Data Collection System
TDM	- Time Division Multiplex
TUR	- Traffic Usage Recorder
TWT	- Traveling Wave Tube
VCO	- Voltage Control Oscillator
VCXO	- Voltage Control Crystal Oscillator